SURGERY, GYNECOLOGY AND OBSTETRICS

AN INTERNATIONAL MAGAZINE, PUBLISHED MONTHLY

VOLUME LIX SEPTEMBER, 1934 NUMBER 3

ACUTE RAPIDLY SPREADING INFECTIONS FOLLOWING TRIVIAL INJURIES OF THE HAND[1]

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IT is particularly appropriate that this group of papers, collected in honor of Dr. Allen B. Kanavel, and of his many years of service as associate editor of SURGERY, GYNECOLOGY AND OBSTETRICS, should include a paper upon acute infections of the hand. There are few more beneficent contributions to surgical teaching and practice than his accurate and clear cut demonstration of the surgical anatomy of the hand and of the routes of extension of infection within the hand and forearm. That demonstration, and the logical methods of surgical treatment deduced therefrom, with their validity supported by many and carefully controlled clinical observations, constitute the basis of his well known monograph, *Infections of the Hand*. Interestingly too, the first edition of that monograph appeared practically in serial form in the first volume of what was then an uncertain venture in the field of medical journalism. We would not venture to estimate how many lives have been saved and how many infected hands have been preserved as functioning members as a result of Kanavel's work. We do believe, however, that his teachings will constitute an enduring commemoration, and that they will continue to exert a directing and beneficent influence upon the treatment of infections of the hand when our generation has become but a memory.

No type of infection can develop more rapidly or become a menace to life with more dramatic and deadly haste than that type of infection variously termed acute lymphangitis, acute spreading cellulitis, acute streptococcic septicæmia, and, by the laity, blood poisoning. Although such an infection can be introduced into the body through any break in continuity of skin or mucous membrane, in our experience it has followed most often a trivial injury of a finger or hand, an infection of the lip or face which has begun as an apparently innocent furuncle, or the extraction of an infected tooth. Of these the acute spreading infections which have followed an injury of the upper extremity have been the most common.[2]

In the series of cases reported in this paper the mortality has been almost one third; but the patients who have survived, and this is the lesson which Kanavel has stressed so often

[2]My first personal contact with such a case made an indelible impression upon my mind, and I have often referred to it since. Nine years ago a junior medical student on his service at the Lying-in Dispensary infected a scratch wound on the dorsum of the right index finger. The finger became somewhat swollen and painful, and he persuaded one of the surgeons in the out patient department to incise it under a local anesthetic. No pus was found. The following day the finger was more swollen and painful; there were a few red lines extending upward along the forearm and the patient was obviously ill. When first I saw him on that day he was told he must go to bed, take as much fluid as possible, put a big warm wet sterile dressing over the entire upper extremity, and that under no circumstances must any one be allowed to incise the finger. He rather protested against this advice because he still thought there was pus in the finger; but since he assured me that he would carry out the treatment faithfully at home and that it would be very inconvenient for him to enter the hospital he was allowed to go.

I heard nothing more from him and had completely forgotten the matter when, a week later, I saw a notice on the bulletin board that the members of the junior class were excused for the afternoon to attend the funeral of this young man. He had gone home from the hospital, persuaded a doctor in his neighborhood to incise the finger, and within 24 hours had developed a severe chill, a temperature of 105 degrees, and all the signs of a malignant generalized infection. Within 48 hours symptoms of a diffuse pulmonary involvement appeared and within another 48 hours he had succumbed to the infection.

[1]From the Department of Surgery, Northwestern University Medical School. Read in part before the Hartford Medical Society, Hartford, Connecticut, April 23, 1934; and the Aux Plaines Branch of the Chicago Medical Society, Oak Park, Illinois, April 27, 1934.

during the past 30 years, have been those who were treated by conservative measures, and in whom active surgical intervention was delayed until there was no question as to the presence of a definitely localized suppurative process.

The cases of acute rapidly spreading infection following trivial injuries of the hand which have come under our observation resolve themselves into 4 definite groups: (1) Those in which the infection gradually subsided and eventually cleared up without local destruction of tissue or abscess formation. (2) Those in which the original injury healed rather rapidly and in which the inflammatory reaction in the hand and forearm disappeared soon after, but in which the axillary lymph glands broke down with resulting abscess formation, sometimes underneath the pectoral muscles. (3) Those in which the infection and the accompanying inflammatory reaction advanced rather rapidly for a time, then came to a standstill, and then gradually receded. As the inflammation receded, localization and abscess formation developed, frequently with extensive destruction of tissue. (4) Those in which the infection advanced rapidly and continued, in spite of every effort to check it, to a fatal termination.

In order to make this presentation as definite and clear cut as possible the cases reported are presented in accordance with this classification rather than in a chronological order.

GROUP 1. RECOVERY WITHOUT LOCALIZATION OF INFECTION OR ABSCESS FORMATION

CASE 1. B. A., Passavant Memorial Hospital, 4095. March 4–10, 1931.

This patient, a physician of 28 years, the day before admission to the hospital struck the dorsum of his left thumb with the end of a glass tube while transferring a culture of a hæmolytic streptococcus. There was no bleeding at the site of injury and he paid no attention to the matter until the following morning, when he noticed redness at the site of the puncture and swelling over the metacarpophalangeal joint. At 9:00 a.m., the swelling had extended to the wrist. At noon there was a row of small painful beads one-half the size of a split pea extending upward along the volar surface of the forearm. At 3:00 p.m. there were three red lines extending from the wrist to the axilla.

On admission to the hospital at 4:00 p.m. his temperature was 99.4 degrees, his pulse 120, his leucocyte count 11,800. About the small puncture wound on the dorsum of the metacarpal of the thumb was an area of redness and swelling about an inch in diameter. The red streaks mentioned extended upward along the lateral and anterior aspect of the forearm, and the medial aspect of the arm.

A large warm wet dressing was applied to the entire left upper extremity and heat maintained over it. The following day the temperature, which had risen to 100.4 degrees the evening of his admission to the hospital, dropped to normal and the red streaks of lymphangitis had disappeared.

March 7 his temperature again arose to 100.2 degrees and he complained of a sore throat. Cultures were made from the secretion of both the nose and throat, and subsequently showed both hæmolytic and non-hæmolytic staphylococci in the nasal secretion and many long chained streptococci in the pharyngeal secretion. When the patient was dismissed from the hospital March 10 he felt well, the signs of inflammation had disappeared from the left upper extremity and his temperature had not risen above normal for 48 hours.

CASE 2. R. K., Rockford Hospital, Rockford, Illinois. September 9–14, 1928.

This patient, a physician of 44 years, sustained an abrasion of the left index finger about September 1, but paid no particular attention to it at the time. Saturday afternoon, September 8, he operated upon a patient with a bartholinian abscess. The same evening he noticed that the finger was inflamed and painful. He felt restless and irritable, and finally went to his office and picked at the finger with a scalpel. All that night the finger and hand throbbed and ached; he was restless and slept very little. Early Sunday morning he called a colleague, who infiltrated the finger thoroughly with procaine, incised it, and stated he was certain there was no pus there, for he incised all the tissues down to the bone.

When I saw the patient Monday evening, September 10, he was obviously very ill. Perspiration was standing in beads on his face and neck; his temperature was 103 degrees; he had had several severe chills. There was a thin serous discharge from an incision ¾ inch in length on the palmar surface of the right index finger. Red streaks extended up the forearm and arm, converging toward the axilla. Fortunately no further surgical treatment had been carried out, and at the suggestion of a former student of Dr. Kanavel, who had seen the patient Monday morning, a massive warm wet dressing had been applied to the entire upper extremity throughout Monday.

This treatment was continued; fluids were administered by mouth and by rectum, and the patient made a gradual and uneventful recovery without definite localization of the infection or abscess formation.

In order to avoid needless repetition, we have included only the above 2 cases of this

group. We have observed 19 other cases with practically an identical story: a slight injury, rapidly developing symptoms of an acute infection, early lymphatic involvement with red streaks extending up the forearm, and in some cases to the axilla, gradual subsidence under conservative treatment of both local and general symptoms, and eventual recovery, without localization or abscess formation, in a period varying from 2 to 10 days.

The course of events in such cases emphasizes the fact that an acute spreading infection can be arrested rather rapidly and without localization or abscess formation if the infection is not of overwhelming virulence, if the resistance of the patient is adequate, and if proper measures to combat the infection are instituted promptly. Such cases give us a certain degree of assurance in that they demonstrate the fact that not every acute rapidly spreading infection is necessarily followed by disastrous results, even though the danger signals—the red lines of lymphatic extension—are present when the patient is first seen.[1]

It is of some interest in connection with this group of cases that none of them under our care received antistreptococcic serum. We have not at any time seen definite indications that it has been of value. It should also be said in fairness that we have not observed any harmful effects in patients to whom serum has been given by others.

GROUP 2. RAPID HEALING OF THE ORIGINAL INJURY AND DISAPPEARANCE OF THE SYMPTOMS OF RAPIDLY SPREADING LYMPHANGITIS; LATER, ABSCESS FORMATION IN OR ABOUT THE AXILLA, SUPRACLAVICULAR OR SUBPECTORAL REGION

CASE 3. E. P. 140033. Wesley Memorial Hospital. August 21–September 6, 1928.

This patient, a girl of 3½ years, on Friday, August 17, fell from a small wagon to the sidewalk and struck her left elbow[2] just breaking the overlying skin. Her mother painted mercurochrome solution over the elbow. The patient felt well until Sunday at 5:30 p.m. when she bumped her elbow and complained of pain. Her father noticed a superficial abrasion, the size of a dime, covered with pus. He wiped it off with a swab saturated with mercurochrome and covered it with gauze. That night, about 1:00 a.m., the patient awoke screaming and trembling; her eyes were staring, and she seemed entirely unconscious of her surroundings for about 15 minutes. At 7:00 a.m. she had a second convulsion.

During most of Monday she was apparently quite normal, but shortly after midnight Monday she had a third convulsion and during the remainder of the night she had repeated convulsions, though not as severe as the first 3.

She was admitted to the hospital at 9:30 Tuesday morning with a temperature of 103.6 degrees, a pulse of 120. Just above the left elbow was a small elliptical denuded area, 1 by 2 centimeters. The arm from elbow to shoulder was swollen and inflamed. The swelling involved the entire axillary region; the axillary lymph glands were palpable and tender. The leucocyte count was 17,900, the erythrocyte count 4,220,000. A massive warm wet dressing was applied immediately to the entire left upper extremity, and 1500 units of tetanus antitoxin injected subcutaneously in the right thigh.

Between August 21 and 25 the patient's temperature fluctuated between 100.2 and 104.8 degrees, the pulse between 100 and 160. In spite of the continuous application of large warm wet dressings there was little change in the appearance of the arm, and the patient constantly seemed very ill and very toxic.

August 25 an area of red mottled discoloration was noted over the medial aspect of the right thigh, and within 24 hours this discoloration had spread and involved the lateral, posterior, and medial aspects of the thigh from hip to knee. Massive warm wet dressings were applied over the entire area, but the swelling and inflammation continued to extend and by August 27 had involved the vulva and perineum. On that day the swelling of the thigh gave a feeling of fluctuation and it was thought liquefaction was taking place. Then, rather rapidly, the inflammatory reaction began to subside, and by August 31 it had practically disappeared from the lower extremity.

In the meantime the inflammatory reaction had also disappeared from the greater part of the left upper extremity, and a definite localized fluctuating mass developed in the left axilla. This was incised September 1 with as little trauma as possible, and about 30 cubic centimeters of thin pus evacuated. Cultures of this pus subsequently showed a pure growth of a non-hæmolytic, short chained streptococcus.

Recovery took place very rapidly after incision of the axillary abscess; the temperature, which had fallen to 98.8 degrees August 31, the day before incision, rose to 100.6 degrees September 1 and there-

[1] Kanavel has suggested that only 10 per cent of cases which begin with an acute lymphangitis go on to localization and abscess formation. That doubtless is a fairly accurate estimate, for the majority of these cases are doubtless seen in the routine of daily practice, and do not come to the hospital or to the attention of the man who confines his work to surgical practice.

[2] This case is 1 of 2 included in the series in which the initial injury was not upon the hand. It is included because the course of events is so definitely similar to that in the remaining cases, and because of the interesting complicating infection in the lower extremity.

after did not rise above normal. The patient was dismissed from the hospital September 6 with the drainage wound almost healed.

CASE 4. H. R., Garfield Park Hospital, 39471. December 29, 1931–January 18, 1932.

This patient, a man of 36 years, sustained a scratch wound of the dorsal surface of the third right metacarpophalangeal joint 12 days before admission to the hospital. The affected hand became painful and swollen, then opened spontaneously and discharged a little pus. The symptoms apparently subsided only to flare up again a few days later, and with the recurrence of inflammation the patient began to have chills, fever, and sweats.

He was admitted to the hospital on the service of Drs. Hatzis December 29 with a temperature of 101.4 degrees and pulse of 110. When I first saw him the same day the wound on the dorsum of the hand had practically healed and the only abnormal finding in the hand and forearm was a slight swelling and œdema as compared with the opposite side. In the axilla, however, and extending down the medial side of the arm was a deeply situated, firm mass over which the skin was tense, reddened, and œdematous.

A massive warm wet sterile dressing was applied over the arm and axilla and the patient urged to take as much fluid as possible. Blood was taken for culture and was later (January 3) reported as showing "a rather scanty growth of Staphylococcus albus." Blood examination December 31 showed 5,100,000 red cells and 13,800 white cells.

January 4 the patient was given a direct blood transfusion of 360 cubic centimeters.

During a period of 11 days, from December 29 to January 8, the patient's temperature ranged between 98.8 and 103.2 degrees, his pulse between 88 and 122. The warm wet dressings were kept almost constantly over the affected area, and the fluid intake maintained at a maximum. The leucocyte count had increased from 13,800 December 31 to 14,000 January 4 and to 18,600 January 8. At the same time the axillary mass had become a little larger, less indurated, and the overlying skin could no longer be moved apart from the underlying mass.

On the afternoon of January 12 the patient's temperature rose to 103.4 degrees, the highest level that it reached at any time. The following morning, under nitrous oxide anæsthesia, the axillary abscess was opened by an incision over the most dependent portion of the fluctuating area, and a considerable amount of thin green pus evacuated, most of it from a definite cavity underneath the pectoralis major muscle. Culture of this pus was reported 2 days later as "practically pure culture of colon bacillus; a few staphylococci present."

The patient's temperature fell to normal the following day and only twice subsequently rose above normal, once to 100 degrees, once to 100.6 degrees. When he left the hospital January 18 the wound discharge had almost ceased.

CASE 5. R. K., Passavant Memorial Hospital, 17196. March 7–April 6, 1934.

This patient, a cooper of 33 years, 2 weeks before admission to the hospital sustained three superficial wounds of his left thumb from the flanged head of a tool which accidentally slipped from his hand as he was driving it against a barrel hoop. Little attention was paid to the wounds at the time. A week later he noticed pain and soreness in the left axilla but he continued work for another 5 days, at the end of which he reported to the company physician with fever, headache, pain in the left upper extremity and exquisite tenderness in the left axilla.

On admission to the hospital 2 days later the patient's temperature was 101.6 degrees, his pulse 100, his leucocyte count 15,700. The original injuries over the left thumb had almost healed but the left axillary region was red, indurated, and tender. The most striking symptom, however, was a diffuse, fiery red, maculopapular eruption which covered his entire body and actually gave him the appearance of a boiled lobster.

For 6 days the patient appeared very ill and toxic in spite of continued application of large warm wet dressings to the entire left upper extremity and forced administration of fluids. During this time his temperature fluctuated between 99.4 and 102.8 degrees, his leucocyte count between 15,000 and 20,000. On March 13, the seventh day after admission, his temperature reached normal for the first time and the erythema was very much diminished. During the next few days desquamation went on rather rapidly, and the skin could be peeled from his trunk and extremities in large dry patches (Fig. 1). At the same time the axillary induration became less marked and less extensive.

March 31, a small well demarcated axillary abscess which had become quite superficial was incised and evacuated. Cultures of the pus showed only a non-hæmolytic Staphylococcus aureus although the symptoms of the infection throughout its course were clearly those of a virulent streptococcus closely allied to the streptococcus of scarlet fever.

CASE 6. R. J., Passavant Memorial Hospital, 4280. October 21, 1930–April 21, 1931.

This patient, an undertaker's assistant of 38 years, while embalming a body Saturday evening, October 18, sustained a scratch wound of the dorsum of the proximal phalanx of the right middle finger. He paid no attention to it until Monday morning when he noticed a little pus draining from the hand at the site of injury. Monday afternoon he had a violent chill and ached all over his body. Pain and tenderness, which during the day had begun to involve the hand, by evening had reached the shoulder. His temperature Monday evening was 104 degrees. A doctor who was called applied antiphlogistine to the hand and forearm.

When I first saw him on Tuesday evening at 6:00 o'clock he was acutely ill, perspiring profusely, and almost in a state of collapse. His temperature was 104 degrees, his pulse 108. His right hand, forearm, and arm were painful to touch, hot and somewhat swollen, though less, he stated, than the day before.

Pain had become fairly well localized to the medial side of the arm and to the shoulder. The axillary and supraclavicular glands were enlarged and very tender. Red streaks, which he had noticed Monday on the medial aspect of the arm, had disappeared. He was admitted to the hospital immediately, a massive warm wet dressing applied to the entire upper extremity and administration of fluids begun.

During the first week in the hospital his temperature fluctuated between 104.4 and 99.4 degrees though after the evening of admission it did not rise above 103 degrees. The symptoms of infection in the hand and forearm cleared up within a few days; but the evidence of deep seated inflammation in the axilla and supraclavicular region became constantly more definite. Eight days after his admission to the hospital it was thought that a definite localization of pus had taken place over the medial wall of the axilla. Under nitrous oxide anæsthesia an incision was made through the thick œdematous subcutaneous tissue and at a depth of ½ inch thin pus was found. Cultures of this pus subsequently showed a pure growth of a long chained hæmolytic streptococcus.

Following drainage of the axillary abscess the temperature level dropped about a degree, ranging between 102.4 and 99 degrees during the second week. During the third week the level was still lower, between 101.4 degrees and normal, though it rose consistently each afternoon to a level of 101 degrees or higher. During the fourth week (November 11–17) the temperature level gradually rose again, to a range between 103.4 and 100 degrees, and with the rise of temperature there developed a widespread inflammation and induration of the entire dorsal surface of the trunk, beginning above over the lower cervical vertebræ and gradually extending downward. November 17 there was noted a painful swelling over the left ninth, tenth, and eleventh ribs and red streaks running downward and forward toward the left groin. With widespread application of warm wet dressings the inflammation gradually became less marked and by November 24, the end of the fifth week, the temperature had reached a normal level.

During the sixth week the temperature again began to rise and as it did so signs of an abscess just inferior to the medial end of the right clavicle appeared. This was opened at noon, December 2, and the area of fluctuation found filled with hæmolyzed blood. This material when cultured also showed a pure growth of a long chained hæmolytic streptococcus. Because of a persistent tendency toward oozing after incision the incised area was packed rather tightly with gauze, but it continued to bleed throughout the course of the afternoon and evening. At ten in the evening the patient was again taken to the operating room, a small bleeding vessel in the wall of the cavity ligated, and pressure maintained over the incised area until every evidence of oozing had disappeared. Two days later, because his red cell count had dropped to 4,200,000 and his hæmoglobin to 75 per cent, he was given a transfusion of 450 cubic centimeters of citrated blood.

Following transfusion the patient's condition improved very definitely and the temperature dropped to a level of 99.4 to 98.2 degrees only to rise again by December 17 to 100.6 degrees as a definite swelling began to appear over the anterior aspect of the sternum. A few days later this swelling disappeared as the accumulated pus ruptured into the area previously drained by the infraclavicular incision, and the temperature again receded. Such a train of events occurred five times subsequently with localization of infection in a pocket posterior to the original axillary abscess January 15, lower down on the chest wall January 30, over the medial end of the clavicle February 22, over the anterior aspect of the right shoulder March 4, and in the middle portion of the supraclavicular region March 24. As each localized area was drained (two accumulations were allowed to rupture spontaneously) the patient's temperature receded, and his general condition improved.

He was dismissed from the hospital April 21, exactly 6 months after his admission, with all the drainage wounds healed and after his temperature had remained normal for 17 days.

Case 7. F. C. Passavant Memorial Hospital, 7728. September 4–October 1, 1931.

This patient, an engineer of 35 years, on Monday, August 24, sustained a cut of the left thenar eminence from broken porcelain. He went to a physician immediately who cleansed the wound and sutured it. Within 24 hours the thenar area was red and tender, and red streaks appeared extending upward over the volar surface of the forearm. The sutures were immediately removed from the wound, and some thin bloody discharge was evacuated. A dressing saturated with mercurochrome solution was applied.

When I first saw the patient 7 days after the injury he was in bed at his home and looked ill. His temperature was 102 degrees. The swelling about the site of injury had diminished, and there was little discharge from the open wound. The forearm and arm showed no evidence of active inflammation, but in the axilla underneath markedly indurated skin and subcutaneous tissue was a firm tender mass about the size of a baseball. The patient, who had been going to the doctor's office each day for dressings, was put to bed and a large warm wet dressing was applied over the entire axillary area. September 4, 11 days after the injury, he was admitted to the hospital. On admission his temperature was 100.8 degrees, his pulse 88, his leucocyte count 10,600. The axillary mass had become a little larger, the skin over it had become red and inflamed and there was a definite sense of fluctuation over its central portion.

The following morning under ethylene anæsthesia the abscess was opened and a considerable amount of thick green pus was evacuated. Cultures of this pus after 48 hours showed a pure growth of a non-hæmolytic streptococcus. Twenty-four hours after operation the patient's temperature had dropped to

normal, and remained normal for 36 hours. September 7, 2 days after incision of the axillary abscess, it was evident that some pus had accumulated at the site of the injury in the palm. This was opened through a small incision in the line of the original injury. Shortly afterward the patient's temperature began to rise and in 24 hours had reached 104.2 degrees. At the same time redness and tenderness appeared over the line of the brachial vessels over the medial aspect of the arm. For 48 hours the patient's temperature fluctuated between 98 and 103.2 degrees and he felt and looked very ill. At the end of that period the temperature receded, and September 11 again reached normal and remained at a level of 98 to 99 degrees for 6 days. During this time the inflammatory reaction disappeared entirely from the hand and almost completely from the axilla, but the redness and inflammatory reaction over the medial aspect of the upper arm continued in spite of the persistent application of warm moist dressings. September 17 the temperature began to rise again and as it did so evidence of subcutaneous abscess formation appeared over the middle of the arm in the line of the brachial vessels. September 20 the skin at this site broke down and thick yellow pus was discharged from the opening. September 22, under ethylene anæsthesia, the infected area was opened more widely. The same afternoon the temperature, which had remained at a level of 100 to 102.4 degrees for 4 days, again dropped to normal, and remained normal until the patient was dismissed from the hospital 9 days later. At this time there was only a small amount of thin seropurulent discharge from the open wound on the medial aspect of the arm, but some destruction of skin and subcutaneous tissue had taken place and at the edge of the denuded area the skin was undermined and indurated. The long and narrow open wound showed little tendency to heal, and it was more than 2 months after the patient left the hospital before the raw surface was completely covered with epithelium and healing complete.

This group of 5 cases includes 2 of the most difficult cases, with the exception of the fatal cases, in the entire series; and the case (No. 6) in which the question of recovery or of a fatal outcome remained for the longest time in doubt.

One important element in the seriousness of these cases lies in the fact that the infection has broken down the main line of defense—the axillary lymph glands, and if by any mischance in incising an abscess one breaks through the limiting wall of leucocytes and fibroblasts the liberated infectious material finds ready access into the open lymphatics that lead directly into the systemic circulation.

The group as a whole helps to emphasize again the fact, so often stressed by others, that simply incising an abscess due to a hæmolytic streptococcic infection can cause a recrudescence of symptoms and a severe generalized reaction, and that it is the part of wisdom to limit one's surgical procedures to the very minimum—a simple incision, without retraction, without stretching of the wound edges and without digital exploration of the abscess cavity. In Case 6 we finally permitted the abscesses to rupture spontaneously, and felt that in so doing we were giving the patient the greatest measure of safety.

GROUP 3. RECOVERY WITH LATE ABSCESS FORMATION

CASE 8. C. H., St. Luke's Hospital, 258935. June 2–18, 1930.

This patient, a physician of 51 years, sustained an injury of the volar surface of the distal phalanx of the right index finger Saturday, May 31, 1930. Just after exploring an empyema cavity with the right index finger he turned toward the instrument table and struck the gloved finger tip, covered with pus, against a sterile hypodermic needle attached to a syringe projecting over the side of the instrument table. He continued with the operation and paid no further attention to the injury. The next day the finger became painful and tender to the touch, and he was conscious of throbbing pain when he held the hand in a dependent position.

I saw him first Monday morning, 42 hours after the injury. The distal phalanx was moderately swollen, and very sensitive to light touch; but it was not tense, as is the distal phalanx with the typical infection of the anterior closed space. At the center of the volar surface could be seen a tiny discolored point at the site of the puncture wound.

I urged him to enter the hospital immediately and have a large warm wet dressing applied to the entire upper extremity. By the time he reached the hospital, approximately 2 hours later, red streaks had appeared on the volar surface of the forearm and extended upward to the elbow. At that time his temperature was 98.6 degrees, his pulse 88, his leucocyte count 15,500.

A large warm wet sterile dressing was immediately applied to the entire extremity, an electric baker placed over it, and administration of fluids begun. During the next 4 days the swelling of the finger gradually increased, and slowly extended to the hand. The patient's temperature fluctuated between 99 and 102.8 degrees but for the most part remained close to 101 degrees (Fig. 2). The leucocyte count also fluctuated from day to day (Fig. 3). As the infection extended upward (Fig. 4) the symptoms of toxic absorption became more pronounced and the patient complained of persistent and intense

pain of such a degree that hypodermics of ¼ grain of morphine gave relief only for 2 hours. At times he would become irrational and think that he was at work in the operating room.

June 6, 4 days after admission to the hospital, it was evident that the index finger was definitely enlarged as compared with the others. It was held in semiflexion but no especial tenderness could be elicited by gentle pressure over the tendon sheath. The epitrochlear and axillary glands had become definitely enlarged. A culture of the pus recovered from the empyema cavity was reported as showing a pure growth of a hæmolytic streptococcus.

The following day, June 7, the swelling of the entire index finger was definitely and markedly increased. Under nitrous oxide anæsthesia the finger was opened by a lateral (radial) incision extending from the middle of the distal phalanx to the level of the metacarpophalangeal joint. Thin, milky pus filled both the subcutaneous tissues and the tendon sheath; in other words, the infectious process involved not only the tendon sheath but all the tissues of the finger including the soft tissues of the distal phalanx. Since gentle pressure over the thenar space caused an escape of pus from the proximal end of the incision in the finger the thenar space was opened through an incision on the dorsal surface of the hand at the radial side of the second metacarpal bone. Cultures of the pus subsequently showed a heavy growth of Streptococcus hæmolyticus and a scant growth of Bacillus pyocyaneus.

Following incision and drainage the patient's condition gradually improved. Two days after operation a dusky red area of gangrene of the subcutaneous tissues at each side of the incision over the distal half of the finger became apparent, and eventually went on to a considerable loss of subcutaneous tissue.

The hand was dressed daily with every care to maintain asepsis so as to preserve if possible the flexor tendons. They were still intact, but exposed in the depth of the wound when the patient left the hospital June 18. The same careful treatment, with dressings saturated with Dakin's solution, was continued at the patient's home, but in spite of it the tendons became necrotic and the digital portions of the flexor tendons had to be removed from the finger. Healing of the finger was complete August 15, 2½ months after the original injury.

Case 9. C. D., Cook County Hospital, 1277486. March 18–April 2, 1932.

This patient, a laborer of 41 years, 2 days before admission to the hospital stuck himself with a needle over the middle of the palmar surface of the middle phalanx of the right index finger. The next day because of pain and swelling he "scraped it with a razor blade." Twenty-four hours later he was admitted to the hospital with a temperature of 103 degrees, and a pulse of 112. The entire right hand and forearm were swollen and inflamed; red streaks were present along the medial side of the arm. The epitrochlear glands were enlarged and tender.

Immediately after admission a massive warm wet dressing was applied to the entire right upper extremity and continuous heat applied over it. With continued warm wet dressings, complete bed rest, and a forced fluid intake the symptoms of infection gradually subsided. March 25, 1 week after admission to the hospital, a large blister which had formed over the palm between the base of the index finger and thumb ruptured spontaneously and about an ounce of thin yellow pus was discharged. Thereafter the patient's temperature receded to normal and he was dismissed from the hospital April 2 with a slight seropurulent discharge still present from the palmar wound at the base of the index finger.

Subsequently, April 27, because the wound discharge continued and the index finger remained stiff in extension he was readmitted to the hospital, the incision made along the radial side of the index finger reopened and the soft œdematous and semi-necrotic flexor tendons removed from within the tendon sheath. Healing followed without further complications.

Case 10. M. E., Nurses' Infirmary, Cook County School of Nursing. December 3, 1932–January 24, 1933. February 28–March 16, 1933.

This patient, a nurse of 30 years, reported to Dr. Paul Rhoads on the morning of December 3 with swelling and throbbing pain in the left thumb and hand. The day before she first noticed slight pain in the left thumb; during the night the pain became intense and throbbing, and by morning there was definite swelling involving the thumb and thenar area. She could recall no definite injury involving the thumb.

On admission to the hospital her temperature was 100.2 degrees, her pulse 98. The palmar surface of the left thumb and thenar eminence was swollen, red, and tender. The patient was put to bed, a large warm wet dressing was applied to the left upper extremity, and fluid given in maximum amounts. During the next 7 days her temperature ranged between 98 and 102 degrees, her pulse between 80 and 120. The area of inflammation and swelling gradually extended upward (Fig. 5) and was more pronounced on the radial side of the hand and forearm. December 11 and 12, particularly, she complained of tension and "drawing" in the hand and forearm; she said it felt as though the hand would burst. Any movement of the thumb or wrist caused exquisite pain. December 14 the patient seemed better, the hand and forearm were less painful, and movement of the thumb caused less pain. December 15 a small area of localized redness and fluctuation began to appear at about the center of the radial half and lower half of the volar surface of the forearm. The following day this area of redness and fluctuation was more definite and more extensive.

On the afternoon of December 16, under nitrous oxide anæsthesia an incision was made on the radial side of the forearm just volar to the subcutaneous border of the radius. When the fascial attachment of the flexor carpi radialis was divided the radial

bursa could be seen bulging into the wound. When it was opened about 4 or 5 ounces of green pus were evacuated from both the radial bursa and the common flexor sheath. The sheath of the long flexor tendon of the thumb was then opened in the palm and the same type of green pus found. The flexor tendon of the thumb was bright and shining.

Cultures of the pus from both forearm and hand subsequently showed a pure growth of a hæmolytic streptococcus.

Thereafter improvement was definite and progressive but complicated by the development of two other conditions.

December 24 the patient was up out of bed for 15 minutes for the first time. December 25 at 3:30 a.m. she suddenly felt a sharp vise-like pain in the left arm, shoulder, and left side of the chest, including the cardiac area. Associated with it she had difficulty in breathing. The duration of the attack was about a half hour. There was no cough or expectoration associated with it, but a slight rise in temperature, to 99.6 degrees, and an increase in pulse rate to 120. Physical findings were entirely normal. She had never had a similar attack before.

December 26 she complained of pain in the left lower chest and lumbar region, a pain different from that present the day before and similar to pain she had experienced on previous occasions. Throughout the next day she complained of persistent pain on attempting to void and at 9:00 p.m. passed some blood clots and urinary gravel.

January 2 she had an attack of nausea and vertigo associated with a subnormal temperature, a cold clammy skin and a rapid irregular pulse. This attack lasted about 3 hours. January 4 she had another attack of pain in the left kidney region. Thereafter she gradually gained in appetite and strength and was dismissed from the infirmary January 24 with the drainage incisions in the hand and forearm almost healed.

February 28 she was readmitted to the Nurses' Infirmary complaining of severe pain over the precordium, tachycardia, and palpitation, shortness of breath, and daily fever from 99 to 99.6 degrees. She stated that following the initial attack of anginal pain December 25 she had not had any similar severe pains until the preceding day, but that she had had a constant slight pain in the chest, and tachycardia and palpitation on the slightest exertion. At 8:00 p.m. the day before admission she was suddenly seized with a vise-like pain over the center of the chest which radiated across the precordium and down the left arm to the wrist. This continued for several minutes and was accompanied by marked dyspnœa and a feeling of fear that she could not breathe again. After a few moments the sharp pain disappeared, but was followed by less intense pain which persisted. These symptoms, with a slight daily rise in temperature, persisted during the 16 days of the patient's stay in the hospital. At the end of that time she was ordered to return to her home for a prolonged period of rest.

Case 11. M. P., Passavant Memorial Hospital, 16192. December 7–30, 1933.

This patient, a woman of 59 years, sustained a slight penetrating wound from a chicken bone over the volar surface of the interphalangeal joint of the right thumb Sunday morning, December 3. The wound bled freely; it was only washed with water at this time. The same afternoon the patient began to have pain, which increased in intensity and became throbbing by evening. During the night she slept very poorly, and had several chills. Monday morning her temperature was 102 degrees. Swelling of the thumb, which had begun Sunday evening, had extended to the hand. On the advice of a physician hot antiphlogistine was applied to the hand, but without helpful effect.

Tuesday, December 5, the swelling began to extend up the forearm and red streaks appeared extending as far as the elbow. About 2:00 a.m. Wednesday morning, because of the intense pain, her physician inserted a needle into the soft tissues just proximal to the web between the index and middle fingers and between the middle and ring fingers, and attempted unsuccessfully to aspirate pus.

On Thursday morning, December 7, when I first saw her she was irrational and moaning with pain. Her face was hot and flushed, her temperature 102 degrees, her pulse 100. The entire hand and forearm were tense, inflamed, and swollen. Red lines of lymphatic involvement extended upward along the medial surface of the arm.

She was admitted to the hospital at 11:00 a.m., a massive warm wet sterile dressing immediately applied to the entire upper extremity, and an electric baker placed over the whole upper extremity. On admission her temperature was 101 degrees, her pulse 100, her leucocyte count 13,250. During the first 24 hours in the hospital she received 5140 cubic centimeters of fluid orally and by proctoclysis, and at no time during her stay of 24 days did the fluid intake fall below 2900 cubic centimeters during a 24 hour period.

The evening after her admission to the hospital, December 8, her temperature dropped to normal and although the swelling and tension in the upper extremity gradually receded, severe pain, particularly at night, remained a distressing symptom and necessitated the use of codeine and aspirin in order to secure rest.

December 11 the continuous warm wet dressing was discontinued and instead the hand was soaked twice daily for 15 minutes in a warm, sterile bath, and after each soaking dried out under the electric baker. During the next 10 days the patient's condition gradually improved, her temperature remained at or below normal the greater part of the time and only on two afternoons rose above 99 degrees; once to 99.6 degrees, once to 99.4 degrees. The swelling of the hand and forearm, however, did not completely disappear; it seemed to change from time to time and not to recede steadily.

December 21, the lower part of the forearm just above the wrist was definitely more swollen and painful than it had been. The afternoon temperature which had been 99 degrees the day before rose to 100.6 degrees. The white cell count which on 4 examinations had fluctuated between 11,750 and 14,800 rose to 18,000. December 22, the swelling and redness above the wrist were still more marked. The following morning, under nitrous oxide anæsthesia and through a bloodless field, the radial bursa was opened through a lateral incision just volar to the lower end of the radius. Thick green pus in considerable amount was evacuated from the radial bursa and the retroflexor space above the wrist (Fig. 6). A second incision was made over the sheath of the flexor longus pollicis in the palm and a small amount of similar pus was released. Culture of the pus subsequently showed a heavy growth of Streptococcus viridans in pure culture.

Recovery thereafter was rapid and uneventful. The temperature dropped to normal at noon December 24 and only once thereafter was recorded as above normal. The white cell count dropped from 18,000 to 8,750 on December 24. The continuous warm wet dressings, which had been reapplied December 22, were discontinued December 27, and the patient dismissed from the hospital December 30 with the operative wounds healing and with very little wound secretion. She returned to the hospital for dressings every second day for a few times and subsequently at longer intervals until the operative incisions were completely healed January 15, 1934.

Throughout her stay in the hospital every effort was made to maintain the function of the hand, by keeping it in the position of function while it was enveloped in a massive wet dressing and by keeping up movement of the fingers and wrist during the free intervals after the continuous wet dressing was discontinued. When she left the hospital she could close the fingers into the palm fairly well, and bring the tip of each finger to the thumb. The range of movement February 21, 2 months after operation, is shown in Figure 7.

Case 12. S. J., Cook County Hospital, 1417343. February 27–March 24, 1934.

This patient, a colored man of 20 years, sustained two small deep knife wounds of the right palm and a number of lacerations of the forehead and face Saturday night, February 24. He was admitted to the hospital shortly afterward, and the wounds cleansed and sutured; he was dismissed from the hospital the following day. Tuesday evening, February 27, he was readmitted to the hospital because of pain, swelling, and evidence of spreading infection in the right hand and forearm. The sutures were immediately removed from the hand and a warm wet dressing applied to the entire right upper extremity.

When I first saw him 2 days later with Dr. Earle Greene the patient was obviously very ill. The entire hand and forearm were swollen, tense, and hot. Although his skin was very black two dusky red

a. b. c.

Fig. 1. Case 5. Extensive desquamation following a generalized, maculopapular, erythematous eruption, subsequent to a slight injury of the left thumb (a) and a severe spreading infection.

bands of lymphatic involvement could be clearly seen extending upward along the volar aspect of the forearm and the medial aspect of the arm as high as the axilla. The treatment which had been instituted on his readmission to the hospital was faithfully continued, and fluids given in maximum amounts. March 9 evidence of a localizing infection on the radial side of the lower half of the forearm began to appear. Conservative treatment, however, was continued until March 13 when it was quite certain that a definite abscess had developed. This was opened under nitrous oxide anæsthesia by an incision along the radial side of the forearm just volar to the subcutaneous surface of the radius, and by a second incision through the palmar skin and fascia at the site of the larger original wound, a half inch to the radial side of the midline of the palm and one inch distal to the wrist joint. Thick gray pus was evacuated from the abscess in the retroflexor space, which extended ulnarward to the midvertical line of the forearm and upward 2½ inches from the wrist and, through the second incision, from underneath the palmar fascia. (It was obviously from infection introduced underneath the palmar fascia through the wound distal to the wrist joint that the acute spreading infection had developed.)

Cultures made from the pus subsequently showed a pure growth of a hæmolytic streptococcus.

Following incision and drainage healing took place rather rapidly. By continually urging the patient to keep his hand in a position of supination, and by beginning movement of the fingers soon after incision of the abscess a fair degree of mobilization of the fingers and wrist had been attained when the patient was dismissed from the hospital March 24, with the drainage wounds granulating and with little wound discharge remaining. The function of the fingers and hand May 1, 3½ months after the initial injury, is shown in Figure 8.

Case 13. A. R., Passavant Memorial Hospital, 16053. November 25–December 9, 1933.

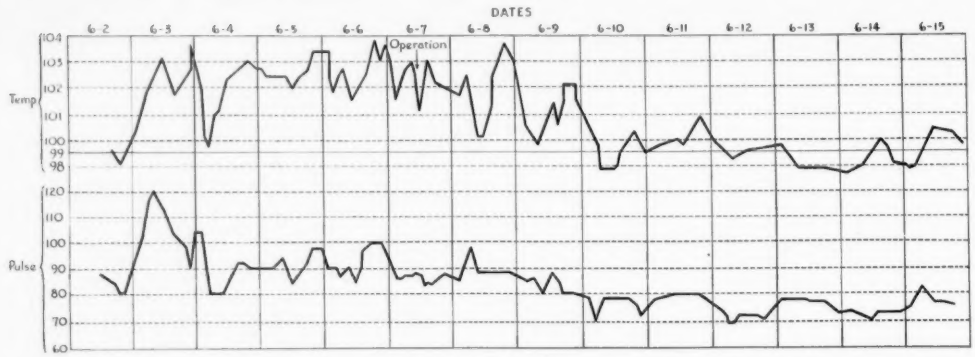


Fig. 2. Case 8. Temperature and pulse curve of patient with pancellulitis of index finger following puncture wound of distal phalanx.

This patient, a housewife of 40 years, on Saturday, November 4, while cutting carrots sustained a cut, so slight that it did not bleed, on the volar surface of the right thumb at the level of the interphalangeal joint. On the following Monday or Tuesday it became painful. She applied iodine to the thumb and began soaking the hand in hot boric solution. The swelling increased rapidly involving particularly the thumb and thenar area; the index and middle fingers also became stiff and painful.

Saturday, a week after the initial injury, she first consulted a physician, who advised hospitalization. She was admitted to the South Haven (Michigan) Hospital the same day, and 2 days later the volar and dorsal surfaces of the thumb were incised under ether anæsthesia.

Two weeks later, November 25, she was admitted to Passavant Memorial Hospital where I saw her for the first time. On admission her temperature was 100 degrees, her pulse 124, her leucocyte count 22,500. The urine was heavy with albumin and casts, and contained from 3 to 8 red blood cells and from 50 to 60 pus cells in each high power field.

The hand and forearm were markedly swollen and inflamed (Fig. 6). Thick pus was draining profusely from the incision over the volar surface of the thenar eminence (Fig. 9, a). The hand was held fixed in a position of pronation and volar flexion at the wrist; the fingers were flexed into the palm.

Under nitrous oxide anæsthesia and through a bloodless field an incision was made first over the ulnar bursa in the palm to make certain whether the infectious process had extended distalward along the ulnar bursa from the forearm into the hand (Fig. 9, c). At this point the subcutaneous tissues were not œdematous and the normal appearing flexor tendons of the little finger could be seen shining through the tendon sheath. The sheath was not opened. A second incision was made above the wrist just volar to the subcutaneous margin of the ulna (Fig. 9, d) and a large amount of thick pus evacuated from the retroflexor space. On gentle palpation the cavity was found to extend across to the radial border of the forearm (Fig. 9, e) and upward to the middle of the forearm. The incision which had been previously made over the volar surface of the thumb was enlarged so as to drain adequately the sheath of the flexor pollicis longus in the palm (Fig. 9, c) and expose the fragmented and semi-necrotic flexor tendon. Large warm wet dressings were applied as high as the shoulder and an electric baker placed over the extremity.

Cultures of the pus obtained from the retroflexor space in the forearm subsequently showed a heavy mixed growth of hæmolytic streptococcus and Bacillus pyocyaneus, and a few colonies of Staphylococcus aureus.

Following operation the patient improved slowly but steadily. November 29, 4 days after operation, intermittent soaking of the hand and forearm in a sterile bath was substituted for the continuous warm wet dressing and in the intervals the hand laid on a light aluminum splint designed to bring it into dorsal flexion at the wrist and permit movement and particularly extension of the fingers. December 2 the albumin and red cells had disappeared from the urine and the leucocyte count dropped to 9100. December 5 her temperature for the first time did not rise above 99 degrees. She was dismissed from the hospital December 9 with the drainage wound on the ulnar side of the forearm red and granulating, but with considerable discharge still present from the incision over the flexor tendon of the thumb. The latter diminished rather rapidly after the remains of the necrotic flexor tendon were lifted from the wound.

Following her dismissal from the hospital every effort was made gradually to increase the movements of the fingers, which were almost fixed in flexion when she was admitted to the hospital, and to overcome the tendency to maintain the hand in pronation and volar flexion at the wrist joint. The progress attained in these respects is indicated in the photographs obtained February 10 (Fig. 10).

Case 14. J. R., Passavant Memorial Hospital, 13564. April 1–18, 1933.

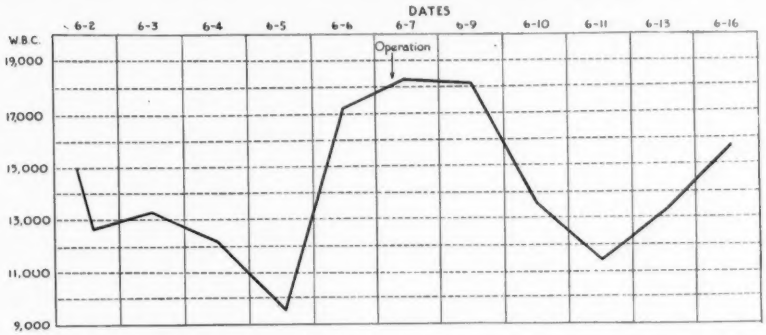


Fig. 3. Case 8. Graph showing variation in leucocyte count during stage of acute infection.

This patient, an iceman of 35 years, sustained a cut over the palmar surface of the interphalangeal joint of the left thumb from a piece of tin projecting from an ice box on Friday morning, March 31. On awakening at 5:30 the next morning he noticed pain and tenderness and slight swelling over the palmar aspect of the thumb. These symptoms increased during the day. At 3:00 p.m. he was sent to a physician, who froze the thumb with ethyl chloride and incised it. Within a few moments the patient was seized with a chill and complained of feeling very ill. He was immediately put in a cab and brought to the hospital.

When I first saw him at the hospital at 4:15 p.m. his temperature was 103.8 degrees, his pulse 96; he was still trembling and complaining of feeling cold. The left thumb was bleeding at the site of the palmar incision in the distal phalanx. The entire thumb was dusky and moderately swollen. A broad red band could be seen extending upward along the middle of the volar surface of the forearm, turning posteriorly over the medial aspect of the elbow. A large warm wet dressing was immediately applied to the entire upper extremity and forced administrations of fluids begun.

During the next 4 days the patient's temperature fluctuated between 100 and 104.6 degrees, his pulse between 80 and 110. He complained bitterly of the persistent pain, and was constantly drenched in perspiration. His leucocyte count on admission was 18,200; April 4 it had dropped to 9100. On April 4 the tension and tenderness over the entire palm, the exquisite pain produced by even slight passive extension of the semiflexed fingers, the numbness of the finger tips, the tension and tenderness over the wrist joint, and the tense brawny swelling of the volar surface of the forearm pointed toward the extension of infection upward along the radial and into the ulnar bursa (Fig. 11), and possibly already rupturing from the bursæ into the retroflexor space above the wrist. The persistent presence, however, of a band of redness, an inch in width, extending upward over the medial aspect of the arm, the obvious prostration of the patient and the sharp drop in the leucocyte count made us very apprehensive that any operative procedure would be followed by a severe reaction and a rapidly developing and probably fatal septicæmia.

Conservative treatment was therefore continued. April 5 the temperature fell a little lower, and 2 days later dropped below 100 degrees for the first time. April 6 the hand and forearm were both less tense and the red band over the medial aspect of the arm had disappeared. April 10 although the upper two-thirds of the forearm were still swollen the tense brawny induration had been replaced by a rather soft œdema. April 11 the leucocyte count had risen to 13,200 and the lower third of the forearm was beginning to show a slight bulging swelling as compared with the upper two-thirds. By this time, because of the constant application of the warm moist dressings, considerable maceration and superficial necrosis had taken place, particularly over the volar and dorsal aspects of the wrist (Fig. 12).

April 13 under nitrous oxide anæsthesia the hand and forearm were incised. The four typical incisions for drainage of the ulnar bursa in the palm, of the

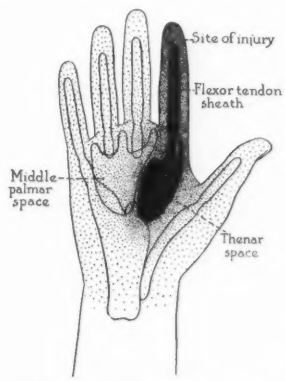


Fig. 4. Case 8. Diagram showing site of injury and extension of infection. Stippled area indicates extent of intense inflammatory reaction; solid black area, site of abscess formation.

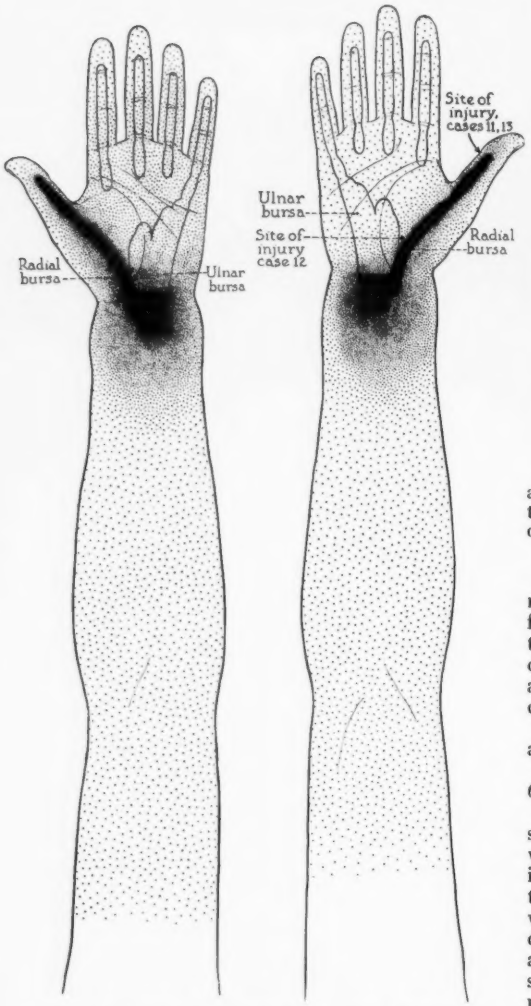


Fig. 5, left. Case 10. Diagram showing site of injury and extension of infection. Stippled area indicates extent of intense inflammatory reaction; solid black area, site of abscess formation.

Fig. 6. Cases 11 and 13. Diagram showing sites of injury and extension of infection. Stippled area indicates extent of intense inflammatory reaction; solid black area, site of abscess formation.

flexor tendon sheath of the little finger, of the retroflexor space above the wrist and of the tendon sheath of the flexor pollicis longus in the palm were made. Pus was evacuated through each incision. Cultures of the pus obtained from the ulnar bursa in the palm (the first space incised) subsequently showed a pure growth of a non-hæmolytic streptococcus.

Fig. 7. Case 11. Degree of function present 12 weeks after injury, and 9 weeks after incision and drainage of tendon sheath of flexor pollicis longus in the palm, and of radial bursa and retroflexor space in the forearm.

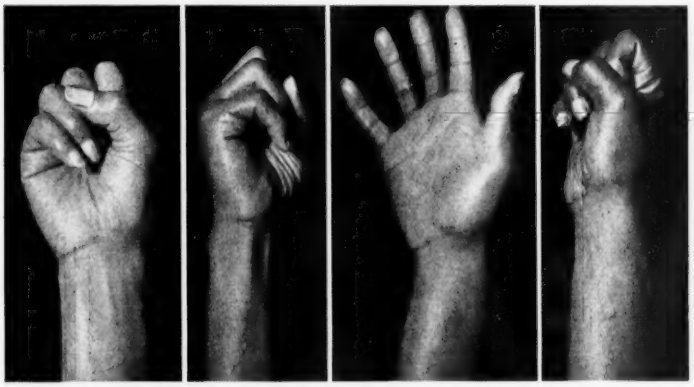
Following operation the patient improved rather rapidly. From April 15 to 18, the day of his dismissal from the hospital, his temperature ranged from 98.2 to 100 degrees and reached the latter level only once during the 4 days. April 18 he was transferred to another hospital so that he might be under the direct care of his company doctor.

The condition of his hand 6 weeks and 9 months after operation is shown in Figures 13 and 14.

Case 15. S. P., Passavant Memorial Hospital, 6289. April 28–May 29, 1931.

This patient, a butcher of 45 years, accidentally scratched the volar surface of his left thumb while at work Monday, April 20. He paid no attention to the injury and continued with his work. In the evening the thumb felt stiff and painful, but no treatment was instituted. He continued work for the next 3 days, but by the evening of April 23, the entire hand and wrist had become swollen, red, and painful. In spite of increasing symptoms of inflammation and of upward extension of the infection he refused to enter the hospital until the afternoon of April 28. At that time his temperature was 104.2 degrees, his pulse 104. The entire left hand, wrist, and forearm were tremendously swollen and inflamed. Over the dorsum, particularly, the skin was tense from tension and over a few small areas superficial necrosis had already taken place. Above the area of diffuse redness, red streaks of lymphatic extension could be seen extending upward above the elbow.

With constant application of large warm wet dressings to the entire upper extremity the process gradually subsided and then receded in a step like descent. By May 9 it was obvious that a localized abscess had formed over the dorsum of the metacarpus, and a small incision was made under nitrous



a. b. c. d.

Fig. 8. Case 12. Degree of function present 13 weeks after injury, and 11 weeks after incision and drainage of retrofascial space in the palm and of radial bursa and retroflexor space in the forearm.

oxide anæsthesia over the dorsum of the second metacarpal.

Cultures of the thin pus evacuated subsequently showed a pure culture of a hæmolytic streptococcus.

Warm wet dressings were continued for another 7 days; then intermittent soaking and dry dressings were substituted for the continuous wet dressing, and movement of the fingers begun. When the patient was dismissed from the hospital May 29 the drainage wound was almost healed and he was moving his fingers fairly well.

CASE 16. H. B., Cook County Hospital, 1272431. February 17–March 1, 1932.

This patient, a laborer of 54 years, sustained a superficial laceration over the dorsum of the middle metacarpophalangeal joint of the right hand in a fist fight Monday afternoon, February 15. Wednesday morning he awoke with a severe pain in the hand, and was admitted to the hospital at 2 o'clock the same afternoon.

On admission his temperature was 101 degrees, his pulse 88, and he was obviously very ill. The hand was greatly swollen, the dorsal surface was dusky, of a reddish purple color. Over the middle metacarpophalangeal joint was a small laceration from which thin pus was draining. Definite red streaks extended upward over the dorsum of the forearm and medial surface of the arm. No glands could be palpated in the epitrochlear region or axilla.

Massive warm wet dressings were applied immediately to the entire extremity and continuous heat maintained over them with a "light cradle." The routine of forced fluids and continued bed rest was faithfully carried out. During the succeeding 5 days swelling and redness gradually extended farther proximalward until it reached the junction of the upper and middle thirds of the arm; then it began gradually to recede. On February 24 it was evident that a considerable accumulation of pus had formed under the skin over the metacarpus (Fig. 15). This was drained under nitrous oxide anæsthesia by a single incision over the center of the fluctuating area. A considerable quantity of pus was evacuated. Smears of the pus showed large numbers of streptococci and clusters of staphylococci. Cultures of the pus subsequently showed both the streptococcus and staphylococcus to be hæmolytic.

Warm wet dressings were reapplied to the hand and forearm and continued for 4 days. Intermittent soakings, followed by dry dressings, were then substituted for the continuous warm wet dressings and the wound discharge was very markedly diminished when the patient was dismissed to the out patient department March 1.

CASE 17. E. B., Passavant Memorial Hospital, 8794, 9013. December 14, 1931–January 2, 1932; January 6–16, 1932.

This patient, a physician of 35 years, while performing an autopsy Sunday morning, December 13, sustained a slight knife cut over the dorsum of the left little finger just distal to the proximal interphalangeal joint. He stated that the autopsy was on the body of a patient who had died of a bone sarcoma; that 25 days earlier an autopsy had been performed on the body of a patient with a virulent streptococcic infection, and that 2 other autopsies had been performed in the interim. Immediately after the injury he took off his glove and kept his hand wet until the autopsy was completed, some 20 minutes later. He then washed the finger with 80 per cent alcohol solution and applied a dressing.

At 9:30 p.m. he first noticed pain about the site of injury. He held the hand for an hour under warm running water and then applied a dressing saturated with hexylresorcinol. At 2:00 a.m. he awoke with sharp pain and a feeling of tension about the site of injury. He applied a warm boric dressing and went back to sleep; at 4:00 a.m. he again awoke with pain

a. b. c. d. e.

Fig. 9. Case 13. Infection of tendon sheath of flexor pollicis longus, of radial bursa, and of retroflexor space of forearm after a slight injury of volar surface of thumb. a, b. Before operation. c, d, e. Immediately after operation. Note in c exploratory incision for examination of ulnar bursa in palm, and incision for drainage of tendon sheath of flexor pollicis longus in palm; and in d incision for drainage of retroflexor space in forearm.

in the hand. At that time he first noticed red streaks extending up the forearm and arm. His temperature at that time was 103 degrees.

I first saw him at 9:00 a.m. Monday, 22 hours after the injury. A small amount of seropurulent discharge was oozing from the ¼ inch cut on the dorsum of the little finger. The dorsal surface of the finger was swollen; the hand was slightly swollen. On the dorsum of the forearm were several irregular and indistinct red streaks. Over the middle of the medial aspect of the arm were two distinct red streaks, ⅛ inch wide and ⅜ inch apart, extending straight upward to the axilla. No axillary glands could be palpated.

When he reached the hospital, a half hour later, his temperature was 100.6 degrees, his pulse 98, his leucocyte count 18,800. A large warm wet dressing was immediately applied to the entire left upper extremity and an electric baker placed over it.

During the succeeding days the patient became intensely ill. The swelling and inflammation of the hand gradually increased and extended upward above the elbow. A peptic ulcer, which had previously responded well to mucin treatment, flared up and gave him very acute distress. December 16 the red streaks had completely disappeared. December 18 the swelling and inflammation had reached to the junction of the lower two-thirds and the upper one-third of the arm. There it remained stationary for a few days, and then gradually began to recede. December 22 the redness and swelling had practically disappeared from the arm, and the forearm was less swollen; a sense of deep fluctuation over the dorsum of the hand suggested that localization might be taking place. December 23 a large, thin walled blister had formed over the dorsum of the metacarpus. When the blister was punctured considerable thin gray pus escaped and a small opening could be seen in the skin over the middle of the metacarpus from which similar pus was escaping. Culture of this pus subsequently showed a heavy growth of a hæmolytic streptococcus and an occasional colony of staphylococci.

The continuous warm wet dressing, which had been replaced by an intermittent wet dressing for 3 days, was reapplied but no attempt was made to enlarge the small drainage wound or to facilitate the escape of pus. During the next 24 hours there was a profuse discharge of thin grayish purulent material and the opening in the skin increased to a diameter of ⅛ inch. Twenty-four hours later, on Christmas day, the patient had a chill; his temperature, which had been remaining at a level of 99 to 100 degrees, rose abruptly to 103.8 degrees and his leucocyte count to 26,000 (Fig. 16). There was no evidence of thrombophlebitis, but a little more swelling and redness of the lower forearm with some indications of abscess formation there. A second opening also appeared distally and to the ulnar side of the first opening, and in the meantime the first had increased somewhat in size. During the next 24 hours the temperature dropped almost as abruptly as it had risen, and reached normal at noon December 26. Thereafter it did not rise above 98.8 degrees. The wound discharge gradually diminished, and as it did so the redness and swelling of the forearm receded.

January 6 the wound discharge had become seropurulent and very thin. The raw surface on the dorsum of the metacarpus had increased to a diameter of ¾ inch and was becoming covered with granulation tissue (Fig. 17, a). The dorsum of the fingers, hand and wrist was constantly of a dusky red color but the inflammatory reaction had practically disappeared from the forearm. When the patient was dismissed from the hospital January 19 the open wound at the site of drainage was almost healed.

The final result is shown in Figure 17 b, c.

Fig. 10. Case 13. Degree of function present 4 months after operation.

Case 18. M. D., Nurses' Infirmary, Cook County School of Nursing. March 25–May 6, 1933.

This patient, a nurse of 21 years, scratched herself on the dorsum of the right thumb with her left thumb nail 2 days before admission to the hospital. The day after the injury the right thumb became sore; the same evening she noticed signs of inflammation and a red streak extending upward along the dorsal aspect of the thumb. She was admitted to the hospital on the following day on the service of Dr. Paul Rhoads with a temperature of 100 degrees, and a pulse of 136. At that time the redness and swelling had extended upward to the middle third of the forearm and the patient complained of intense pain in the inflamed area. A large warm wet dressing was immediately applied to the right upper extremity and external heat maintained over it.

During the next few days the inflammatory process gradually extended proximalward, and as it did so the swelling of the dorsum of the hand became less indurated. The patient's temperature in the meantime fluctuated between 98 and 103 degrees, her pulse between 96 and 142, and her leucocyte count between 19,000 and 13,600. March 29 under nitrous oxide anæsthesia three longitudinal incisions were made over the dorsum of the hand by Dr. Edwin Miller and a considerable amount of yellow pus evacuated. Cultures of this pus subsequently showed a pure growth of a hæmolytic streptococcus.

In spite of the liberation of pus from the dorsum of the hand the inflammatory process continued to extend upward. March 31 a second operation was performed by Dr. Miller, and an incision 12 inches long was made from the dorsum of the hand almost to the elbow. Through this incision a considerable amount of free pus and sloughing tissue was evacuated from the dorsal aspect of the forearm.

When I saw the patient first on April 3 she was complaining of pain over the medial aspect of the arm. The soft tissues above the elbow were red and inflamed, but not indurated. Massive warm wet dressings were applied as high as the shoulder and conservative treatment advised. Thereafter the inflammatory process gradually subsided and no further extension took place. April 25 Dr. Miller was able to excise the granulation tissue from the forearm wound, undermine the skin edges and bring them together with silk sutures. No reaction developed after this procedure and the patient was dismissed May 6 with the drainage wounds almost healed, but with a short rough systolic murmur at the apex which was not present when the patient was admitted to the infirmary, and which Dr. Rhoads believed had developed during the course of her infection.

Following her discharge from the hospital she remained at home until June 26 and during that period gained 20 pounds in weight. On her return to duty the systolic apical murmur first noted May 2 was still present but she showed no evidence of cardiac embarrassment.

Case 19. R. K., 1340936. Cook County Hospital. February 17–28, 1933.

This patient, a girl of 4 years, was admitted to the children's surgical ward with a history of pain and swelling of the left forearm of 5 days' duration. She

first complained of tenderness and pain Sunday night, February 12. The next morning a doctor who was called noted that the child was feverish and fretful, and that there was limitation of motion of the left upper extremity. By Wednesday the forearm had become swollen and red "in spite of the cold applications and the rubbing with oil of wintergreen," as prescribed.

On admission February 17 the patient was feverish and irritable. Her temperature was 103.2 degrees, her pulse 100, her leucocyte count 16,800. The palm of the left hand was swollen and tense, the entire forearm inflamed, brawny, and indurated. There was some swelling above the elbow. A large warm wet sterile dressing was applied to the entire upper extremity and a "light cradle" kept over it continuously.

Four days later it was obvious that liquefaction had taken place and that the brawny indurated mass had become converted into a sac of pus. Through a 2 inch incision on the medial aspect of the lower end of the forearm a large quantity of thick fluid pus, lying superficial to the deep fascia, was evacuated. Cultures made from the pus subsequently showed a pure growth of a hæmolytic streptococcus. Following incision recovery took place rapidly and the patient was dismissed from the hospital February 28 with a flat granulating wound at the site of the drainage incision.

Although in this case we had no history of an injury of the hand as the etiological factor for the rapidly spreading infection, the course of events so closely simulates that seen in a number of other cases that we feel justified in including this case with the group under discussion.

Case 20. J. R., 1257693. Cook County Hospital. November 24, 1931–February 10, 1932.

This patient, a workman of 28 years, sustained a penetrating wound of the dorsum of the left hand just distal to the metacarpophalangeal joint of the middle finger, from a steel nail, 36 hours before admission to the hospital. He paid no attention to the injury at the time of its occurrence, but 12 hours later pain became so severe that he was unable to sleep, and at the same time he noticed swelling and red streaks extending upward toward the elbow.

On admission to the hospital the hand was swollen and œdematous, particularly on its dorsal aspect. A small puncture wound could still be seen over the base of the middle finger. Numerous red lines were present over the forearm and arm extending upward to the cubital and axillary fossæ. "Hot spreads" were applied and antitetanic serum given.

When I first saw the patient 3 days later his temperature was fluctuating between 100 and 103 degrees; his pulse between 110 and 120. The entire left upper extremity had become swollen, inflamed, and indurated. The superficial tissues over the dorsum of the hand and wrist were undergoing necrosis and thin yellow pus was oozing from these areas. Here and there over the dorsum of the forearm were large blisters filled with thin turbid fluid. The whole extremity had a dusky, cyanotic tinge, and over the medial aspect of the arm were still present red bands indicating the extension of the infection along the main lymphatic trunks. The appearance of the upper extremity at that time is well illustrated in the colored frontispiece (Fig. 18).

For the next week conservative treatment was continued; the entire extremity above the wrist was kept enveloped in a large warm wet sterile dressing; over the hand and wrist, because of the maceration and necrosis of the superficial tissues, dressings saturated with Dakin's solution were applied and changed twice in each 24 hours. Fluid was given in maximum amounts and pain controlled with opiates. From November 27 to December 5 the patient's temperature ranged from 99 to 103.4 degrees; the pulse from 88 to 120. December 5 evidence of softening appeared over the dorsum of the forearm, and within 48 hours the diffuse brawny induration which had extended from the wrist to the axilla was replaced by widespread softening and fluid formation. December 7, under nitrous oxide anæsthesia, two longitudinal incisions were made in the forearm and one above the elbow so as to secure maximum and dependent drainage. Liquid pus literally poured from each incision; it seemed as though the entire mass of subcutaneous tissue had been transformed into fluid and stringy necrotic material. At no point was there evidence that the infection involved the deeper tissues or that abscess formation had taken place underneath the deep fascia.

Thereafter recovery was slow, but uneventful. December 21 the patient's temperature became normal. December 23 two incisions were made in the forearm to secure better drainage, for in two areas wound discharge tended to become pocketed underneath the overlying skin. As invariably happens with drainage incisions made on the dorsum of the forearm, wide separation of the skin edges at the sites of incision took place, and healing was delayed by this separation and because of the extensive necrosis of skin and superficial tissues on the dorsum of the hand and wrist which had occurred in the course of the first week.

When the patient was dismissed from the hospital February 10 the granulating wounds were quite small. The appearance of the hand and forearm and the range of movement present March 15, 1932, are shown in Figure 19.

Case 21. M. H., Cook County Hospital, 1321918. November 7–December 14, 1932.

This patient, a Mexican workman of 45 years, sustained a slight penetrating wound from a piece of wire over the dorsum of the metacarpophalangeal joint of the left middle finger 5 days before admission to the hospital. Pain, redness, and swelling of the dorsum of the hand appeared within 12 hours.

On admission to the hospital the entire hand and forearm were inflamed, markedly swollen, and indurated, the swelling had already extended above the elbow, and over the medial surface of the arm were two distinct red bands extending to the axilla.

Several large blisters had formed over the dorsum of the hand and wrist, underneath them necrosis of the skin had taken place, and from the open wounds there was a profuse discharge of light yellow seropurulent fluid.

Shortly after admission the entire upper extremity was surrounded with a massive warm wet sterile dressing and external heat was applied over it with the aid of a "light cradle." This treatment was continued for the next 5 days, fluids were given in as large amounts as possible, and sedatives to control the pain. In spite of the fact that his recorded temperature and pulse rate did not rise above 102 degrees and 108 during this period, the patient's condition obviously became increasingly serious. During this period, also, the swelling of the hand and forearm gradually increased and involvement of the arm became more marked. Except over the dorsum of the hand, where the tissues had broken down, the swelling was everywhere brawny, indurated, and resistant to the touch; the entire upper extremity was livid, with a persistent cyanotic tinge.

On the fifth day after admission to the hospital a diffuse softening of the firm and indurated subcutaneous tissue began to develop in the upper extremity. Within 48 hours the entire forearm and arm were literally transformed from a uniformly tense, indurated mass into an elongated sac of pus. On the seventh day, under nitrous oxide anæsthesia, three vertical incisions were made at the most dependent portion of the extremity as the patient lay with his arm extended—one over the lower portion of the forearm, one over the upper, and one above the elbow. Liquid pus literally poured from each incision; the entire mass of subcutaneous tissue seemed to have been converted into fluid and stringy necrotic material, but the process did not extend beneath the deep fascia nor were the muscles or tendons exposed.

Following operation the patient's temperature promptly dropped to normal, the abdominal pain and distention, which had developed during the days immediately preceding the operation, disappeared and recovery gradually took place. A profuse purulent discharge from the operative incisions persisted for some time, but gradually diminished with the aid of irrigation with Dakin's solution and care not to reinfect the open wounds.

The patient was dismissed from the hospital December 14, 1932, exactly 1 month after operation, with the raw surfaces almost healed. At that time the largest unhealed area and the greatest amount of scar tissue formation were over the dorsum of the hand and wrist, where necrosis of the superficial tissues had been most marked and had taken place early in the course of the disease.

CASE 22. E. N., Cook County Hospital, 1402782. December 15, 1933–January 20, 1934.

Six days before admission this patient, an undernourished and rather frail old man of 68 years, fell and injured his right hand. He was treated at the Green Street Shelter, but swelling and inflammation began soon after the injury, and gradually involved the forearm and arm.

On admission to the hospital on the evening of December 15 he was obviously very ill; his temperature was 103.6 degrees, his pulse 92. The hand, forearm, and arm were inflamed, swollen, tense, and indurated. Over the dorsum of the thumb was a small infected ulcer. The epitrochlear glands were enlarged and tender.

The entire upper extremity was enveloped in a warm wet dressing and forced administration of fluids begun. For the next 7 days this treatment was maintained, although in view of the patient's age and general condition it seemed unlikely that he could overcome the widespread infection. During this time he was constantly irrational and incontinent; his recorded temperature ranged between 100 and 103.6 degrees, his pulse between 88 and 104.

December 22, 7 days after admission, it was evident that the indurated subcutaneous tissue had undergone extensive liquefaction. Under local anæsthesia with 1 per cent novocain the forearm and arm were incised and a profuse amount of pus liberated. Following operation his condition gradually improved. His temperature dropped to normal December 27; at the same time the involuntary urination and defæcation ceased, except for an occasional lapse, and in spite of pressure sores which had developed during the period of incontinence he was able to sit up in a wheel chair on January 6.

The profuse purulent drainage from the forearm and arm gradually diminished with the aid of irrigation with Dakin's solution, and, later, daily soakings in warm sterile soapy water; and he was discharged from the hospital January 20 with only a slight amount of serous drainage at the site of the operative incisions.

This group of cases, in which the inflammatory process advanced very rapidly at first, then more slowly, then became stationary, and finally receded, is of particular interest because it is especially in this group of cases that we believe the function of the hand and in some cases the patient's life were saved by careful nursing and careful surgical treatment.

A number of interesting facts stand out in connection with this third group. First, that infections arising on the palmar surface of the hand and fingers are particularly serious, and that of the infections arising on the dorsum those which begin in the middle finger spread upward most rapidly. These clinical observations are in accordance with two facts, pointed out by Poirier and Cunéo and frequently emphasized by Kanavel, that the collecting lymphatics of the hand and forearm pass from the volar to the dorsal surface and then extend

proximalward (Fig. 19); and, second, that while the collecting lymphatics from the ulnar side of the hand drain into the epitrochlear glands, and those from the radial side of the hand into the axillary glands, the lymphatic vessels from the middle of the hand tend to pass by epitrochlear and axillary glands and drain into the supraclavicular glands, or even into the main lymphatic channels that join the subclavian vein (Fig. 21).

With reference to the first fact—that the direction of lymphatic drainage is from the volar to the dorsal aspect of the hand and forearm—it seems unquestionable that the flow of lymph from a site of inoculation on the palmar surface of the hand not only involves all the deeper cellular tissues of the hand as the infection is carried proximalward and dorsalward but that it can also result in infection of one or more of the synovial lined cavities—the tendon sheaths, the radial and ulnar bursæ, and the joints of the wrist or carpus—as the lymphatic stream drains proximalward. Once infection enters such a space it tends to spread rapidly and without hindrance throughout the extent of the space. Absorption from such an extensive area is marked; it can be likened to the absorption which takes place on a larger scale from the large serous cavities in the abdomen and chest. Further, secondary extension into all the adjacent tissues will undoubtedly take place rapidly if a wide area of involvement, such as an infection of the entire radial bursa for example, is present.

If the original site of inoculation, on the contrary, is on the dorsum of the hand the direction of lymphatic drainage from this site is upward toward the elbow and axilla, but not toward the volar surface of the forearm and arm. As the infection spreads the latter areas gradually become involved by direct extension, but the involvement affects particularly the subcutaneous tissues, and we have not at any time seen abscess formation within a flexor tendon sheath or within the radial or ulnar bursa in a patient in whom the infection started in a wound of the dorsal surface of the hand. In other words, if the infection begins on the palmar surface of the hand because of the direction of lymphatic drainage the entire hand and forearm become involved; if the infection arises on the dorsum the tendency is for it to spread upward in the subcutaneous tissues and remain confined to the dorsal surface and to the subcutaneous tissues of the volar surface.

The course of events in this group of cases followed one of three fairly distinct and characteristic patterns, and we believe this fact also deserves emphasis. The first pattern was seen in patients with infections beginning on the volar surface of the hand (Cases 8–14). In these cases the early symptoms, in addition to rapidly ascending inflammation and rapidly increasing swelling of the hand, of the forearm, and in some cases of the arm, were persistent, excruciating, throbbing pain, and a feeling of excessive tension. These patients persistently complained that the hand and the lower part of the forearm felt as though they would burst. On gentle palpation one could not find evidence of excessive tension over the area complained of; nor, in the cases in which the infection began in the thumb (Cases, 10, 11) did there seem to be an increase of pain on gently extending the thumb—a symptom to which Kanavel ascribed the greatest importance in recognizing the presence of infection within the tendon sheath. After a few days these symptoms become less marked, though we never noticed in these cases any diminution of sensation in the area of median or ulnar nerve distribution,[1] a well recognized but late symptom of infection spreading from the radial to the ulnar bursa, or vice versa, through the common flexor sheath above the wrist.

After varying periods the swelling and tension recurred, but the second time with definite symptoms of a localizing infection—localized redness, localized swelling, and fluctuation. When this area of localized infection was finally incised and drained, healing took place rather rapidly.

Interestingly enough in both of these cases (Nos. 10 and 11) as well as in a third case (No. 13) of this group in which the infection began on the volar surface of the thumb, the

[1] We cannot say that this may not have been present; it was not consistently looked for.

abscess formation took place in the tendon sheath of the flexor pollicis longus, the radial bursa, and the common flexor sheath above the wrist, but did not extend into the ulnar bursa within the palm and the tendon sheath of the little finger (Figs. 5, 6). This fact suggests the possibility that when pus forms rather slowly within a serous lined cavity (the tendon sheath), as a result of lymphatic drainage into it rather than direct inoculation of the opened sheath, there is time for a walling off process to develop,[1] and rapid extension along all the communicating channels is not so likely to take place, particularly if some barrier, such as the taut anterior annular ligament pressing upon the bursa from above, is present to help obstruct the pathway. In the only case (No. 14) of this group in which the infectious process did extend along all the communicating channels i.e., from the tendon sheath of the thumb and radial bursa into the ulnar bursa, distalward in the palm and finally into the digital sheath of the flexor tendons of the little finger (Fig. 11)—the extension took place rapidly and the symptoms of such extension were present 4 days after the initial injury. Because of this patient's serious condition, however, operation was delayed in the belief that early incision would prove disastrous, and the actual demonstration of the spread of infection was delayed for 13 days. In Cases 10 and 11, on the other hand, definite symptoms of infection within the sheath of the long flexor tendon of the thumb and within the radial bursa were not present for 14 and 20 days respectively, after the onset of the infectious process and in these cases the suppurative process did not extend along the entire pathway, i.e., it did not extend into the ulnar bursa within the palm and the digital sheath of the little finger (Figs. 5, 6).

The 2 other patterns in this group were seen in patients with infection beginning on the dorsum of the hand. In these cases one of two things occurred. In certain cases (Nos. 15–18) the swelling and inflammatory reaction extended rather rapidly up the forearm, then more slowly up the arm and finally came to a halt at a level somewhere between the level of the elbow and the shoulder. After remaining stationary for from 24 to 72 hours the swelling and inflammatory reaction gradually began to recede and eventually abscess formation took place, usually over the dorsum of the metacarpus. In 4 other cases (Nos. 19–22) the swelling and inflammatory reaction progressed in the same way until the whole upper extremity was tremendously swollen and diffusely indurated. After remaining apparently stationary for several days, rather suddenly, within 24 or 48 hours, the tense and indurated subcutaneous tissue was transformed into fluid and the upper extremity changed from an indurated cylindrical mass into an elongated sac of pus.[2] When this was opened and drained it was found that the liquefaction and pus formation was confined to the subcutaneous tissues, and lay entirely outside the deep fascia.

GROUP 4. FATAL CASES

CASE 23. V. M., Jasper County Hospital, Rensselaer, Indiana. June 10, 1933.

This patient, a frail 4 year old girl, sustained an abrasion of the hypothenar eminence of the left hand on June 6. The hand was washed and bandaged. Two days later a dry crust had formed at the site of injury. The same afternoon she fell in the street, striking the hypothenar eminence of the same hand against the curb. The dry crust was broken and some bleeding took place.

The following evening, June 9, because she complained of a sore throat, she was taken to the office of Dr. M. D. Gwin. He found the tonsils and pharynx acutely reddened, but no yellowish patches or membrane could be seen. The mucous membrane of the mouth and gums was normal. Over the hypothenar eminence of the left hand was a dark crust surrounded by a circle of acute inflammatory reaction. The patient's temperature was 103 degrees. The hand was dressed with a wet dressing and the patient told to report the next day.

The next morning, according to the mother's statement, a bluish area had appeared at the center of the palm. The parents and patient immediately started for the hospital 15 miles away, but by the time of their arrival the entire hand had become swollen and cyanotic. The patient was immediately put to bed, a massive warm wet dressing was applied, and fluids were given by proctoclysis. In spite of these measures the swelling and cyanosis extended upward with almost incredible rapidity. When I saw the child at 5:00 p.m. she was very restless and

[1] The slowly penetrating gastric ulcer with local peritonitis, as distinguished from the acute perforation with rapidly developing and widespread peritonitis may offer an analogy.

[2] This is the type of case which Kanavel has described so well under the heading "Gangrenous Infections" (*Infections of the Hand*, 6th ed., pp. 238–247).

tossing about in delirium. The swelling had involved the entire upper extremity and the hand itself had become cold and lifeless. During the remaining 5 hours of life the discoloration and cyanosis continued to spread, and had involved practically the entire body when the child died at 10:00 p.m., 54 hours after the second injury.

CASE 24. V. M., Nurses' Infirmary, Cook County School of Nursing. April 1–7, 1932.

This patient, a nurse of 24 years, pricked her right thumb with a pin the day before admission to the infirmary. Soon after she noticed pain and redness in the thumb. Two days before admission she had received her first immunizing dose of scarlet fever toxin, and the evening before admission she felt chilly, had a headache, sore throat, and diffuse muscular pains.

She was admitted to the infirmary under the care of Dr. Paul Rhoads at 3:00 p.m., April 1, obviously acutely ill, with a temperature of 104 degrees, and a pulse of 126. The right thumb was red, swollen, and tender, particularly over the palmar aspect of the distal phalanx. The palm and dorsum of the hand were not yet involved. Red streaks of lymphatic involvement extended upward along the volar surface of the forearm toward the antecubital fossa. The leucocyte count was 21,600, with 84 per cent of polymorphonuclear cells. A large warm wet dressing was applied to the right upper extremity and forced administration of fluids begun.

When I saw her first on the afternoon of April 4 she was complaining bitterly of persistent pain in the hand and forearm. The swelling and inflammatory process had extended upward, and now gave the picture of an acute, diffuse cellulitis involving the entire hand and forearm. Over the palmar surface of the distal phalanx of the thumb at the site of the original injury was a vesicle filled with dark serum. Over the medial aspect of the arm were red lines extending toward the axilla. Although the patient complained of intense pain, gentle movement of the thumb toward extension did not cause exaggeration of the pain.

During the succeeding days her condition grew steadily worse. April 6 the thumb, index finger, and thenar eminence had become gangrenous and the phlegmonous process had involved the entire arm. Although her temperature fluctuated between 98 and 101 degrees until 24 hours before death her pulse rose in almost an unbroken line from a level of 100 just after admission to 170 just before death at 1:40 p.m., April 7.

Cultures of the serum obtained from the blister on the patient's thumb showed a pure growth of a hæmolytic staphylococcus. A blood culture remained sterile after a number of days' incubation.

CASE 25. P. F., Nurses' Infirmary, Cook County School of Nursing, October 16–20, 1932.

This patient, a graduate nurse of 28 years, pricked the volar surface of the distal phalanx of the left thumb with a safety pin October 15. Within a few hours she noticed redness and swelling of the thumb, and by evening red streaks on the volar surface of the forearm.

She was admitted to the Nurses' Infirmary on the service of Dr. Paul Rhoads the evening of the following day with a temperature of 99.4 degrees and pulse of 74. The palmar surface of the distal phalanx of the left thumb was swollen and red. Red streaks of lymphatic extension could be seen on the radial side of the lower half of the forearm. A massive warm wet dressing was immediately applied to the entire upper extremity.

During the next 48 hours both the local inflammatory condition and the patient's general condition grew steadily worse. The swelling and inflammation which had begun in the thumb extended upward to the thenar area and the radial side of the forearm. She complained bitterly of intense throbbing, "thumping" pain in the thumb, hand, and forearm, which was only temporarily lessened by sedatives. Both Dr. R. T. Vaughan, who saw her October 17, and Dr. Edwin M. Miller, who saw her October 18, advised continuation of conservative management and of administration of fluid in maximum amounts.

When I saw her on the evening of October 18 her temperature was 100 degrees, her pulse 110. A small area of superficial necrosis had developed about the site of the original pin prick; the tips of the index and middle fingers had become white and insensitive.

The following morning the superficial tissue over the localized area of necrosis on the distal phalanx of the thumb was lifted away and a little thin seropurulent fluid underneath taken for culture. This subsequently showed a pure growth of a hæmolytic streptococcus. No demonstrable exotoxin could be obtained by Dr. Rhoads from the filtrate of this organism. During the day the patient's pulse rose steadily; she complained persistently of pain, and moaned and tossed in a toxic delirium. Her abdomen gradually became distended, and as the swelling of the hand and forearm progressed the distal two thirds of the thumb became cyanotic. She died at noon, October 20, just 5 days after the initial injury.

CASE 26. E. B., Garfield Park Hospital, 30903. January 21–23, 1930.

This patient, a housewife of 35 years, sustained a slight cut of the right index finger as she was peeling an orange on Saturday, January 18. At noon of the following day, when she first became aware of pain and swelling involving the finger and hand, she applied warm boric acid dressings every half hour, phenol and yellow oxide paste "to draw it," but no relief was obtained.

Tuesday morning, January 21, she consulted Dr. W. A. James, and at 10:00 a.m. of the same day was admitted to the hospital with a temperature of 99.4 degrees and a pulse of 86. On admission it was noted that the arm was "tense, hot, and swollen from the shoulder down." Shortly after admission a blood count showed 56,200 leucocytes with 94 per cent polymorphonuclear cells. Hot boric compresses were immediately applied to the entire right upper extremity.

Because of the obvious seriousness of the patient's condition Dr. James called a second surgeon into consultation, who advised immediate operation. At 1:45 p.m. under ethylene anæsthesia incisions were made on each side of the volar surface of the forearm, 2 to 3 inches above the wrist and an equal distance below the elbow, and four rubber drains were inserted underneath or between the flexor tendons from one side of the forearm to the other.

Wednesday, January 22, although her temperature had not risen above 99.6 degrees or her pulse above 110, she was obviously worse. Dr. James noted, "The pulse is rapid. The hand is pale and cyanotic. There is extension of the infection above the elbow; there is great pressure (tension) in the arm."

At 1:30 p.m., at the insistence of the consultant who had made the incisions in the forearm the day before, she was again taken to the operating room and incisions made above the elbow for through and through tube drainage.

At 9:30 p.m. she was given 50 cubic centimeters of antistreptococcic serum. When I saw her shortly afterward she was sitting up in bed with face flushed, eyes alert and the appearance of a person under the influence of some powerful artificial stimulant. Her temperature was 99.6 degrees, her pulse 120. The forearm and arm were greatly swollen. Thin serous fluid was oozing from beside the drains which had been inserted in the forearm and arm. The hand was cyanotic and cold. The thumb, index, and middle fingers were lifeless and insensitive.

Because of the comparatively brief duration of the infectious process, the high leucocyte count, the absence of high fever, and the apparent sturdy constitution of the patient (she appeared to be a strong woman of 165 to 175 pounds) I advised amputation of the arm at the insertion of the deltoid. To this the husband could not make up his mind to consent unless a third physician, a personal friend, concurred in the recommendation. Before this friend could be reached 3 hours had passed by. The change that had taken place in the meantime was startling. Instead of appearing bright and alert the patient was obviously failing rapidly and profoundly toxic. Had I not urged amputation so insistently 3 hours before I would probably have had the courage when consent was finally given to admit that it was then too late.

Operation was carried out as rapidly as possible, but it was of no avail, and the patient died 6 hours later, at 7:35 a.m. January 23, less than 5 days after the initial injury.

Case 27. J. B., Methodist Episcopal Hospital, Indianapolis, Indiana. December 20–24, 1929.

This patient, a physician of 61 years, sustained a penetrating wound of the volar surface of the distal phalanx of the left middle finger Wednesday evening, December 18. He had opened an infected blister for a patient during the afternoon and immediately replaced the scissors in his instrument bag. Later, in reaching quickly into the bag he struck the middle finger against the point of the scissors. He immediately painted the finger with several antiseptics, including phenol. Thursday, a cold day, he took a long walk and became chilled. In the evening the finger began to throb and pain.

He was admitted to the hospital Friday morning on the service of Drs. J. H. Wynn and R. Wynn S. Owen and it was noted, "The left middle finger is swollen, dark, discolored, with appearance of developing gangrene. There is some swelling of the palm. There is lymphangitis extending to the elbow and some epitrochlear enlargement. There is no axillary adenopathy. Patient is very toxic. No heart murmurs can be heard."

In spite of the application of large warm wet dressings the inflammatory process extended upward and the patient's condition grew steadily worse. Sunday morning, December 22, Dr. Wynn noted that the purplish discoloration of the middle finger had become more marked, and a similar change was developing in the little finger. Swelling of the hand and forearm had become more extensive and dark blebs were appearing on the palm and over the volar surface of the wrist.

When I first saw him in consultation with Dr. Owen at 10:00 p.m. Sunday, December 22, the patient looked sick and feverish, his cheeks were hollow, his face moist. He was very restless and anxious. His temperature was 102 degrees, his pulse 110. The left hand was markedly swollen, the forearm moderately swollen; red lines and a band of lymphatic extension were present on the inner aspect of the arm. Both on the palm and dorsum of the hand were many blebs with thin serous fluid oozing from them. The middle and little fingers were purple, the middle apparently completely gangrenous and lifeless from the web distalward; the little finger was not so completely involved. There was no increase of pain on extending the fingers. The thenar eminence was very tense and thickened, with almost a sense of fluctuation. Just above the annular ligament there was definite swelling, but not marked induration. When the skin forming the blebs was cut away the underlying tissues appeared red, œdematous, almost gelatinous in spots, due to the intense œdema of all the tissues.

The question of amputation was considered, but it seemed to us unlikely that the patient would be able to withstand the shock of such an operation, and improbable that the septic process would be checked even by a high amputation.

For the remainder of the history I am indebted to Dr. Owen. Throughout Monday, December 23, the patient's condition grew steadily worse. Râles over the bases of the lungs which had appeared December 21 became more distinct and were heard over a wider area. The breath sounds over the right base became less clear. On December 24 the patient became irrational and the scleræ tinged with yellow. The spreading gangrene had involved all the fingers and there was beginning discoloration over the wrist. The swelling of the forearm and arm were practically unchanged.

Death occurred shortly before midnight December 24.

CASE 28. W. K., Woodlawn Hospital, 1040. September 2–14, 1928.

This patient, a sturdy steamfitter of 48 years, 6 feet 2 inches tall, and weighing about 200 pounds, stated that he had sustained a sliver wound of the left index finger on Saturday morning, September 1. In the afternoon he went to a moving picture show, and there became aware of intense discomfort in his finger. A little later he consulted a physician who applied an ointment and a dressing to the finger. By evening the finger had become swollen and intensely painful. Within another 12 hours the swelling had involved the entire hand, and he felt very ill and feverish.

Sunday morning, September 2, he was admitted to the Woodlawn Hospital on the service of Dr. James T. Gregory, with a temperature of 100.4 degrees and pulse of 100. On admission, in addition to the pain and swelling of the hand, he complained particularly of weakness; he was unable to walk without assistance and had fainted twice before reaching the hospital. It was noted by the admitting interne, "The hand is badly swollen, there are lymphatic streaks to upper arm, the patient is toxic."

Hot boric dressings were applied to the hand and the patient given, first allonal at 9:00 a.m. and an hour later 1/150 gr. scopolamine hypodermically. At 10:30 it was noted "patient tossing and turning continuously." At 11:55 a.m. because he was extremely restless and slightly irrational he was given ¼ grain of morphine hypodermically, this was repeated at 1:00 p.m., 5:45 p.m., and 11:45 p.m.

The next day the interne noted, "Much worse in every way; hand developing blisters"; and the nurse noted, "Dressing changed; large amount of bloody drainage from third finger. Patient has two large blisters on back of hand." The blisters were opened a little later in the day and a considerable amount of bloody fluid evacuated.

Tuesday, September 4, a blood examination showed 4,000,000 red cells, 19,600 white cells, and hæmoglobin of 80 per cent. At noon, under ethylene anæsthesia the hand was examined by Dr. Gregory. The record states, "Examination of hand; probed; found thrombosis; nothing done."

At 7:00 p.m. of the same day when I first saw the patient, the entire hand and forearm were greatly swollen, the arm less so. Red streaks of lymphatic involvement were present on the medial surface of the arm. The thumb, index, and middle fingers were grayish purple in color, and from these fingers the skin was separating in large grayish patches. Over the areas where the skin had been lifted away the underlying tissues were swollen and reddish purple, like raw beef steak which has been exposed to the open air. Under ethylene anæsthesia the middle palmar space and the ulnar bursa above the wrist were opened. A small amount of thin pus was obtained from both spaces. A large wet sterile dressing was applied from the finger tips to the shoulder.

September 5 the interne noted, "Necrosis of hand more extensive; lymphangitis more marked in upper arm and shoulder."

During the succeeding days, although the patient's general condition varied from time to time, he steadily lost ground. The temperature, which had ranged between 99.6 and 102.4 degrees from September 2 to the afternoon of September 5, gradually became higher. The pulse rate remained remarkably constant, varying from 88 to 108.

September 8 he became irrational again and thereafter his mental condition became more and more confused. On the same day the blood culture was reported as showing a short chain streptococcus, and it was noted, "Hand gangrenous, line of demarcation appearing." September 9 it was noted that the shoulder was very red and swollen. September 11 he began to have involuntary urinations and defæcations, and large reddish purple blotches began to appear over the face and left side of the body. On the same day his temperature began to rise to a higher level, and from that day until the evening of his death, September 14, showed an almost unbroken rise from 102 degrees at 8:00 p.m. September 11 to 107 degrees just before death. The recorded pulse rate during the last 4 days was not above 118.

CASE 29. J. H., Cook County Hospital, 1398675. November 25–December 22, 1933.

This patient, a workman of 57 years, who appeared to be 10 years older, was admitted to the hospital 7 days after sustaining a penetrating wound from broken glass on the volar surface of the left forearm[1] 1 inch above the wrist.

On admission to the hospital his temperature was 99.8 degrees, his pulse 88. The entire left hand and forearm were diffusely swollen, red, and tender. A small amount of very thin seropurulent fluid was draining from the oblique volar wound just above the wrist. A large "hot spread" was applied to the entire upper extremity. When I saw the patient first 4 days later his temperature was 103 degrees and he was obviously very ill. He talked incoherently and complained persistently of pain. There was a diffuse cellulitis of the hand, wrist and forearm with marked œdema. Above the elbow were broad red streaks of lymphatic involvement extending proximalward toward the axilla.

After 2 days, during most of which time his temperature had been 103 degrees or higher and his mental condition unimproved, because I thought a localized accumulation of pus had developed underneath the flexor tendons and beneath the site of the original injury an incision was made on the ulnar side of the forearm just volar to the subcutaneous edge of the ulna, and some thin pus, similar to that which had been draining from the superficial wound, evacuated.

During the next 3 days his condition gradually improved and his temperature receded, though he re-

[1] Although the initial injury in this case was upon the forearm and not the hand this case and No. 19 are included as the course of events was identical with that seen in the majority, and because of the special interest associated with the site of localization of the infectious process.

mained very unco-operative, was irrational much of the time and having involuntary evacuations the greater part of the time. December 5 his temperature which had dropped to a level of 101–102.6 degrees (rectal) again began to rise to a level of 103.6–104 degrees, his pulse became irregular, and he became semi-stuporous. At the same time a persistent cough developed with numerous moist râles over both sides of the chest posteriorly and expectoration of considerable amounts of mucus. Three days later a large reddened area appeared just above the buttocks, and this gradually gave way with the formation of a large bedsore. For days he remained irrational and incoherent, with continuous high fever and continuous involuntary evacuations. It seemed almost incredible that he could still cling to life in view of the severity of the infection and his inability to take food though fluid intake was maintained by hypodermoclysis and glucose solution given intravenously.

By December 15 the inflammatory process in the left hand and forearm had receded very definitely and a boggy fluctuating mass had developed over the dorsum of the metacarpus. This was incised without removing the patient from his bed, and a considerable quantity of thin grayish pus liberated. Thereafter his temperature again receded for a few days, but the diffuse pulmonary involvement which had appeared 10 days before gradually became more marked; consolidation developed in both lower lobes and the patient died December 22 from an extensive bilateral bronchopneumonia.

Case 30. E. E. P., St. Mary's Hospital, Streator, Illinois. May 17–28, 1932.

This patient, a physician of 57 years, sustained a superficial tangential knife cut on the radial side of the middle phalanx of the left index finger while performing an autopsy Sunday, May 15, 1932. Monday a blister had formed at the site of injury. Tuesday he was admitted to the hospital and the finger "was opened"; subsequently he developed chills and a temperature of 101 degrees.

When I saw the patient first on Wednesday evening, May 18, in consultation with Dr. Gordon Perisho, there was diffuse swelling of the entire index finger and slight swelling of the thenar area, with tension and throbbing pain in the finger and extending into the palm. The finger was held in slight flexion; on moving it slightly into extension there was no pain, but if further extension was attempted the pain was definite. There was moderate swelling of the palm, some redness of the forearm and arm with red bands of lymphatic involvement extending proximalward. The patient's temperature had ranged between 102.2 degrees, on admission, and 98.6 degrees.

A large warm wet dressing was applied to the entire upper extremity and administration of fluid in maximum amounts begun. The patient was persuaded, with some difficulty, that he must remain quietly and constantly in bed. I did not see him again and am indebted to Dr. Perisho for the subsequent history.

In spite of the continued application of a massive warm sterile dressing the infectious process continued to spread. On Monday, May 23, 8 days after the initial injury, under gas anæsthesia the finger was opened widely and drained. The following day the patient complained that the left foot felt numb. It was noted shortly afterward that the foot had become cold and that no pulse could be felt in the posterior tibial artery or the dorsalis pedis. May 26 he began to hiccough and continued to do so during the day and most of the night. By May 27 the spreading infection had extended upward and involved the entire forearm, and the left foot had become gangrenous. Death occurred shortly after noon May 28.

Case 31. R. S., Passavant Memorial Hospital, 13313. March 6–9, 1933.

This patient, a 22 year old worker in an automobile assembling plant, sustained a number of small superficial slit-like cuts on the lateral aspect of the distal phalanx of the left index finger about February 27th. Iodine was applied over the cuts and no further attention paid to the injury. March 2, 3 days later, while at work he had several severe chills and on coming home in the evening complained of generalized aching pain, headache, and weakness. A physician who was called found the patient's temperature 103 degrees, his pulse 110. He noted two small superficial cuts on the left index finger and an area of localized tenderness in the left axilla. Otherwise the physical examination was negative.

From March 2 to March 5 the patient was treated at his home under a diagnosis of influenza. On the evening of March 5 swelling and redness appeared over the left side of the chest and the left side of the neck, and the physician then realized that the patient was suffering from an extensive spreading cellulitis secondary to an infection beginning in the left index finger.

On admission to the hospital on the service of Dr. Michael Mason at noon, March 6, the patient was obviously very ill. His temperature was 104 degrees, his pulse 134, his leucocyte count 8,300. A widespread area of cellulitis was present involving the left shoulder, left axilla, the left side of the neck, and the left side of the chest as far down as the waist. This entire area was red, swollen, and indurated, with no indication of localization at any point.

In spite of massive warm wet dressings and forced administration of fluids the patient's condition grew steadily worse; the area of inflammation continued to extend upward, downward, and anteriorly over the chest wall, and he died shortly after midnight March 8, 60 hours after his admission to the hospital.

At autopsy, shortly after death, it was noted that the swelling had reached the level of the left ear above and the level of the trochanter below; it extended to the midline of the chest at the level of the nipple, 4 to 5 centimeters beyond the posterior axillary line at the level of the axilla, and as far down the arm as the insertion of the deltoid. On dissection of the left axilla and left side of the neck the sub-

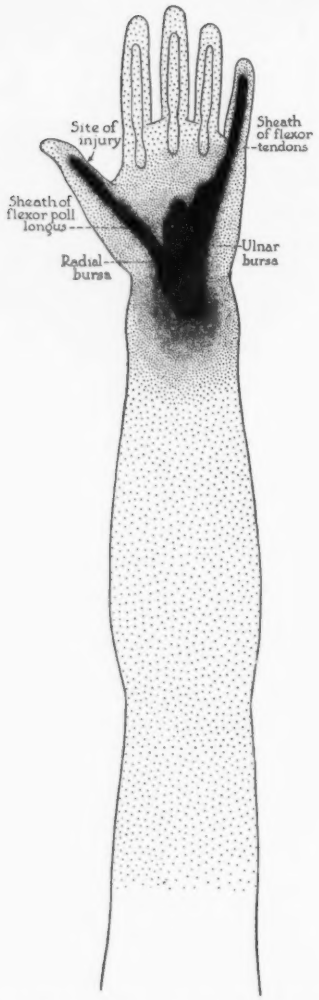


Fig. 11. Case 14. Diagram showing site of injury and extension of infection. Stippled area indicates extent of intense inflammatory reaction; solid black area, site of abscess formation.

cutaneous tissues and intermuscular spaces were found everywhere infiltrated with thin, grayish, turbid fluid which subsequently on culture showed a pure growth of a hæmolytic streptococcus. The other anatomical findings were those of an acute septicæmia (hæmorrhagic serofibrinous pleurisy; acute splenitis; petechial hæmorrhages in renal pelvis and under pericardium and pleura; cloudy swelling of myocardium, liver, and kidneys).

Case 32. C. D. B., Cook County Hospital, 1263061. December 27–29, 1931.

This patient, a laborer of 49 years, was seriously ill when admitted to the hospital the evening of December 27. His temperature was 103 degrees, his pulse 120. He was irrational and unable to give an account of his trouble. His son stated that the patient had sustained a slight injury over the dorsum of the left hand a few days before December 21. In spite of local applications the hand and forearm became swollen and inflamed. On December 21 the swelling had reached the elbow, and the patient's temperature 103 degrees. December 22 he became irrational and about the same time jaundice of the skin and scleræ was noted. He was seen by a physician daily until December 25; on that day sugar was found in the urine, and the physician advised hospital care.

On admission to the hospital the entire left upper extremity above the hand was greatly swollen and inflamed. Although the hand itself was still swollen other inflammatory signs had practically subsided; over the dorsum of the middle metacarpophalangeal joint was the thickened scar of the original injury. The patient was feverish, deeply jaundiced, and stuporous. Addition of 30 drops of urine did not cause reduction of Fehling's solution, but the test for acetone was positive.

A massive warm wet dressing was applied to the entire left upper extremity, fluids were given in maximum amounts and glucose intravenously. These therapeutic measures were entirely without helpful effect; the patient became increasingly stuporous and the jaundice more intense. The acute inflammatory process continued to extend over the shoulder and left side of the body and the patient died 51 hours after admission.

These 10 cases constitute practically one-third of the cases reported in this paper, and one-fifth of the cases observed, if the less serious cases in which an acute spreading infection which subsided rather promptly (within from 2 to 10 days) and without localization or abscess formation are included.

In 7 of these cases symptoms of spreading infection developed within an average of less than 19 hours from the time of injury. Death occurred 8.5 days after the injury. In 2 cases (Nos. 23 and 31) an injury occurred several days before the onset of symptoms. In Case 23 a second definite injury was followed by development of symptoms of infection in less than 24 hours, and by death 54 hours after the second injury. In Case 31 there was not a definite history of a second injury, but no evidence of infection followed until 3 days after the original injuries; then within 5 or 6 hours symptoms of spreading

Fig. 12, a. Fig. 12, b. Fig. 12, c. Fig. 12, d.

Fig. 12. Case 14. Acute spreading infection following injury of volar surface of thumb with subsequent extension into tendon sheath of flexor pollicis longus, radial bursa, common flexor sheath, ulnar bursa, and sheath of flexor tendons of little finger. a, b, c. Appearance of hand just before operation, 14 days after injury. Note swelling and œdema of dorsum of hand and wrist, and swelling of forearm just above anterior annular ligament. d. Appearance immediately after operation. Note incision for drainage of ulnar bursa in palm and bulging at ulnar side of wrist just anterior to site of incision for drainage of retroflexor space in forearm. Because of position of hand incisions for drainage of sheath of flexor pollicis longus and of flexor tendons of little finger cannot be seen.

Fig. 13. Case 14. Appearance of hand 6 weeks after operation. Note areas over which superficial necrosis was present (Fig. 12) are completely healed.

Fig. 13, a. Fig. 13, b. Fig. 13, c.

Fig. 14, a. Fig. 14, b. Fig. 14, c. Fig. 14, d. Fig. 14, e.

Fig. 14. Case 14. Degree of function present 9 months after operation.

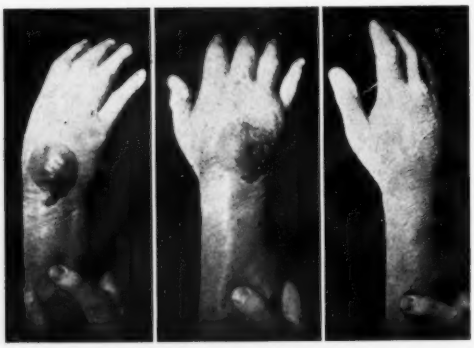


Fig. 15. Case 16. Acute spreading infection following superficial laceration over dorsum of metacarpophalangeal joint of right middle finger. Eventual localization and abscess formation over dorsum of metacarpus.

infection developed, and death followed 4 days after the first appearance of symptoms.

Of the 10 fatal cases 3 had been operated upon one or more times before the patient was seen in consultation. Five had already developed gangrene of one or more fingers when first seen.[1]

The course of events in this group of cases helps to emphasize certain facts. First, that injuries of the volar surface of the hand and forearm are of all most serious, and most likely to go on to a rapidly spreading infection that cannot be arrested. Of the 10 fatal cases the initial injury was upon the volar surface of the hand in 6 cases, and on the volar surface of the forearm just above the wrist in 1 case. In 2 cases the initial injury was on the lateral surface of the left index finger. In only 1 case was the initial injury on the dorsum of the hand; and in that case the injury involved the important middle finger from which the lymphatics frequently lead directly upward into supraclavicular glands or the main lymphatic pathways above the axilla.

Secondly, these cases, as well as those in which recovery took place, emphasize the fact that trivial injuries should not be neglected,[2] and that the site of such an injury should be protected from infection from without until healing is complete. Several of the cases described above, we believe, were not infected with the organisms which produced the fatality at the time of the original injury, but were inoculated through the unhealed wound some days later. This seems the more probable because in the majority of cases it was only a matter of hours between the time of the original injury and the development of symptoms; and because in 1 of the cases mentioned (Case 23) a second definite injury occurred at which the original wound was broken open. In this case the second injury was followed by a rapid development of serious symptoms.

Third, the moment symptoms of infection appear in a finger or hand the patient should be treated by the most effective measures for combating infection which we have at our command. They are simple, but definite: massive warm wet dressings, elevation of the part, administration of fluids in maximum amounts, rest in bed. Too often these measures are delayed for 24 or 48 hours, and an infection, which might have been checked by bringing the normal defensive mechanism into action promptly, gains rapid headway and quickly passes beyond control.

The question is frequently asked, "What should the surgeon do when he accidentally pricks his finger with an infected needle, or when he sustains a penetrating wound while working with infected cases?", and "Should he cauterize such a wound tract with cauterizing agents, or with an actual cautery or attempt to sterilize it with chemical agents?" The methods of treatment mentioned have always seemed to us illogical. It is obviously impossible to know or to see how deeply or in exactly what direction a needle, for example, has penetrated the tissues. If one cauterizes or sterilizes with powerful chemical reagents nine-tenths of a wound tract and leaves untouched the deepest one-tenth virulent organisms left in the depth of the wound are immediately supplied with favorable conditions for bacterial growth: warmth, moisture, and devitalized tissue; and the development of infection is actually favored.

[1] Of the cases which developed gangrene of one or several fingers none recovered.

[2] Only the cases in which an acute rapidly spreading infection followed a trivial injury are included in this series. During the same period in which the above cases were seen a still larger group was seen in which a severe and rapidly spreading infection followed a lacerated or incised wound or a crushing injury of the hand or forearm.

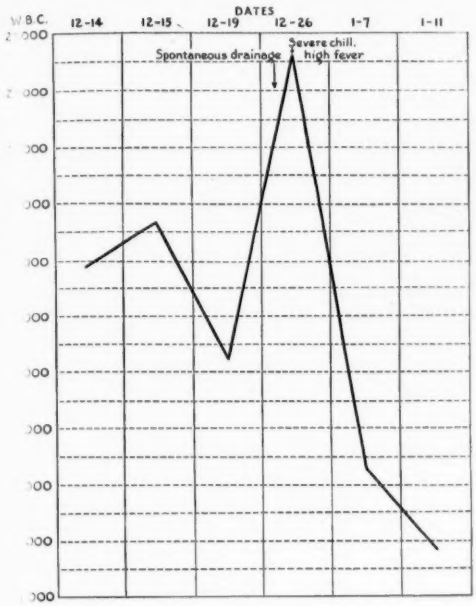


Fig. 16. Case 17. Graph showing variation in leucocyte count during stage of acute infection.

A forceful argument in favor of this contention has recently been added by the experimental work of Hudack and McMaster in demonstrating the rapidity of diffusion of dyes through the lymphatics of the living skin. With the aid of the binocular microscope and photographs (Fig. 22) made with a microcinema camera these workers found that within 30 seconds after beginning an intradermal injection "the plexus of lymphatics showed dye over an area 14 to 15 millimeters in diameter, and in 45 seconds the colored plexus was 2.5 centimeters wide. Within 1 minute and 15 seconds the outlines of the vessels first entered became blurred by dye that had escaped secondarily from them into the interstitial spaces through the lymphatic wall. . . ."

Many experiments led them to conclude "that all slight breaks in the physical barrier of the skin yield opportunity for the passage of dissolved foreign matter into the skin lymphatics, and that the slightest penetration beneath the epithelium opens these vessels to the entrance of particulate matter."

a. b. c.

Fig. 17. Case 17. Acute spreading infection following knife cut of dorsum of little finger, with eventual localization and abscess formation over dorsum of metacarpus. a. Appearance of hand 13 days after localization of infection and spontaneous drainage. b, c. Appearance of hand 2½ years afterward.

Further these workers found that, "5 minutes after the injection dye can usually be seen 15 centimeters away from the injection spot in the draining lymphatic trunks, rendering visible those which lie in the subcutaneous fat. In two instances dye has been perceptible in the draining trunks of the axillary portion of the arm 8 minutes after an intradermal injection of 0.10 cubic centimeter of patent blue V into the volar surface of the forearm." In another case dye could be seen in the lymphatics almost as high as the axilla 6 minutes after an injection into the volar surface of the forearm.

Further studies were made by Hudack and McMaster with intradermal injections of toxins to which dye solution had been added in a ratio of 1 part to 20 or to 10 parts of toxin. In these cases the injected material entered the lymphatic capillaries and passed along the anastomosing channels just as did the dye solution.

In view of all these facts it is impossible to believe that even if one could visualize an infected wound tract perfectly he could sterilize it with a cautery or with chemical reagents simply because of the rapidity with which infected material is carried along the lymphatic channels and away from the site of injury. Until it is possible to develop methods of identifying bacterial types and strains with

Fig. 19. Case 20. Result 4 months after healing of incisions made for drainage of a widespread suppurative process involving entire dorsum of hand, forearm, and lower half of arm. (See frontispiece.)

rapidity and certainty and of obtaining specific antitoxins for them our best resource in treating patients with such injuries lies in helping to insure the efficient working of the method nature has used for many centuries in combating infection; namely, rest, mobilization of the resistant parts of the body by production of an active hyperæmia, and elimination.

Once evidence of rapidly spreading infection has developed the unwisdom of attempting to arrest it by active surgical treatment has been amply demonstrated. The increased permeability of the lymphatics after slight injury as from ultraviolet light or after inflammatory change, demonstrated by Hudack and McMaster in the experiments referred to, furnishes a very logical explanation of this frequently observed clinical fact. Only 1 case of those reported (No. 2) in which operation was carried out early, during the period of active extension of infection, survived, and this patient in our judgment survived in spite of the operation. On the other hand when conservative treatment was carried out until there was positive and unequivocal evidence of localization of infection (cases in groups 2 and 3) recovery almost always took place rather rapidly after drainage of the localized infection had been instituted.

Finally, it has often been said, and we believe with unanswerable logic, that every infected wound should be treated with the same scrupulous care with reference to asepsis that is accorded the clean case in the operating room. Only in this way can the addition of new and different strains of bacteria be avoided, and the patient saved from an added infection to which he may have little or no immunity, or from an infection which in symbiosis with that which is already present may prove particularly harmful. In this connection it is of interest that one patient (No. 13) whose original injury was a cutting wound so slight that it did not bleed, stated that after the thumb was incised the hand with its open draining wound was soaked four times daily in an arm bath, which was not sterilized so far as she knew, and in which the solution was reheated before the soaking several times a day without being changed. The pus evacuated from the retroflexor space of this patient on culture showed a heavy growth of both a hæmolytic streptococcus and bacillus pyocyaneus, and a few colonies of Staphylococcus aureus. It seems entirely logical to think that this mixed infection was an important factor in contributing to the seriousness and duration of her illness and to the ultimate destruction of the tendon in the infected sheath.

Fig. 20. The closely lying lymphatics of the dorsum of the hand, and the anastomosing collecting trunks (from Kanavel and Mason, *The Cyclopedia of Medicine*, vol. vi).

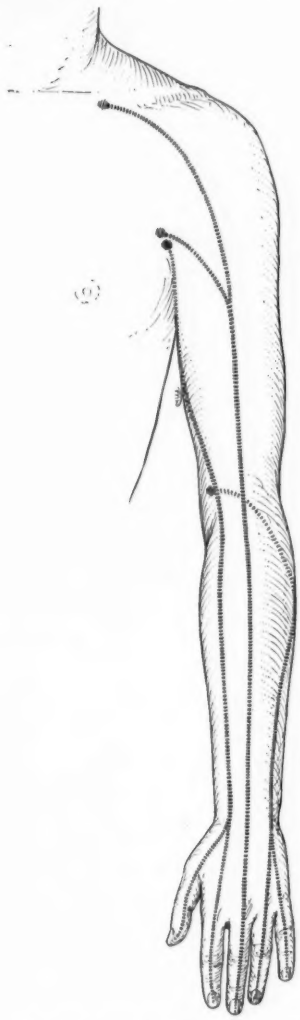


Fig. 21. The main lymphatic trunks of the forearm and arm. Note the direct pathway from the middle finger to the supraclavicular region (from Kanavel and Mason, *The Cyclopedia of Medicine*, vol. vi).

BACTERIOLOGICAL FINDINGS

The term streptococcic septicæmia, so often applied to the types of cases under discussion, is not a misnomer. Of the 2 cases in group 1, 1 patient was infected while transferring a culture of a hæmolytic streptococcus. Of the 5 patients in group 2, with axillary localization, in the most serious case (No. 6) a pure growth of a hæmolytic streptococcus was repeatedly found in the cultures made from pus evacuated from the localized abscesses. In 2 other cases a non-hæmolytic streptococcus was found in pure culture, in a fourth case a colon bacillus and a few colonies of staphylococci. In the fifth case (No. 5) although the clinical picture and the widespread scarlatina-like eruption, followed by generalized desquamation (Fig. 1), were characteristic of a streptococcic infection only Staphylococcus aureus was found in the superficial axillary abscess which was incised some weeks later.

Of the 15 cases in group 3 a pure culture of a hæmolytic streptococcus was obtained from the pus evacuated in 6 cases; in 3 other cases a hæmolytic streptococcus was recovered in conjunction with Bacillus pyocyaneus in 1 case, with a hæmolytic staphylococcus in another case, and with a non-hæmolytic staphylococcus in a third case. In 1 case a pure culture of a Streptococcus viridans was recovered and in another a pure culture of a non-hæmolytic streptococcus. In 4 of the 15 cases in group 3 the bacteriological findings were not available.

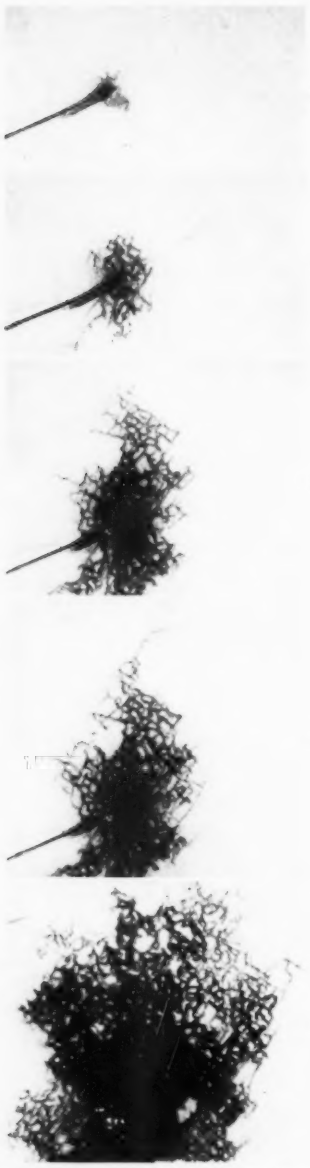


Fig. 22. Successive stages in the distribution of dye during injection of the skin. An 11 per cent solution of patent blue V was injected intradermally and a cinematographic record made of the spread of the solution. The figures here shown were selected from the film to show the course of events. The injection of 0.2 cubic centimeter required 80 to 85 seconds. a, Beginning of injection; b, 30 seconds after beginning injection; c, 45 seconds after beginning injection; d, 1 minute and 15 seconds after beginning injection; e, 30 seconds after cessation of injection. Area in b is 14 to 15 millimeters, in c is 2.5 centimeters. ×1.5 (From Hudack and McMaster, *J. Exper. Med.*, 1933, vol lxvi ,Plate 46.)

In 1 of the 10 fatal cases (No. 24) a hæmolytic staphylococcus was obtained from the serum of a blister that had formed at the site of the original puncture wound. A culture made from the blood of the same patient 1 hours before death remained sterile after a number of days' incubation. In a second case (No. 25) a hæmolytic streptococcus was obtained from the serum of a blister that had formed at the site of the original puncture wound. In a third case (No. 28) a short chained streptococcus was recovered from the blood taken 5 days after the injury and onset of symptoms. This is the only case of the entire series in which a positive blood culture was obtained. In a fourth case (No. 31) a hæmolytic streptococcus was recovered in pure culture from the pus obtained at autopsy from the subcutaneous tissues of the chest wall and axilla.

LATE COMPLICATIONS

We are accustomed to think of involvement of the serous membranes—joint inflammation, endocarditis, pericarditis, etc., of myocarditis and vascular disease as possible sequelæ of the streptococcæmia of scarlet fever and of other infections, particularly epidemic infections. We are likely, however, to forget that such sequelæ can also follow an acute streptococcic infection of the hand and forearm, and that it behooves us to keep this possibility in mind both in suggesting the proper treatment and in making a prognosis.

The history of one patient subsequent to his infection is of sufficient importance to report the details.

This patient, reported as No. 1 in group 1, returned to his work at a research laboratory one week after the subsidence of his symptoms and after his dismissal from the hospital. On March 28, 18 days after leaving the hospital, he first noticed slight irritation of the right eye and a few red striations running outward from the iris. During the next week he noticed marked lacrymation and gradually diminishing vision. By April 6, vision in the right eye was almost gone.

From April 7 to May 7 he was under constant treatment with hot wet dressings over the eye and local administration of atropine.

On May 7 he was admitted to Wesley Memorial Hospital on the service of Dr. P. D. O'Connor and Dr. J. H. Hutton complaining, in addition to the loss of vision in his right eye, of pain in both shoulders, both ankles, the left wrist and thumb, symptoms which had appeared subsequent to the development of the chorioretinitis.

On May 18 a presystolic roughening was heard for the first time along the left border of the sternum. Two days later he had a chill, after which the pain in the joints was much worse, although no redness or other evidence of localized infection could be elicited. For a number of weeks low grade fever, tachycardia, and moderate irregularity of the pulse on slight exertion were persistently present. During this period he had several acute attacks of precordial pain associated with tachycardia, weakness, and almost complete disappearance of the pulse at the wrist.

In the latter half of June he began gradually to improve, the pain in the joints disappeared, and he was able to sit up in bed for an hour twice daily with little increase in the pulse rate.

On September 13 it was noted by Dr. O'Connor, "The right fundus is somewhat hazy, due to vitreous opacities. Temporal to the disc is an area of old choroidal atrophy with a pigmented border. Nasal to and above the disc is a bluish white area with indefinite borders, which is probably the site of the active lesion. The left fundus shows a small healed lesion above the disc."

The following day the patient was dismissed from the hospital and eventually returned to his work, but with marked impairment of vision and of physical strength.

The development of a short rough apical systolic murmur during the course of her infection in the patient reported as Case 18, and of definite symptoms of myocardial damage in the patient reported as Case 10 have already been told. The patient reported as Case 8 developed mild anginal attacks during the years immediately following his infection, but paid little attention to them. June 4, 1934, he developed an acute attack of coronary thrombosis and died after an illness of less than 48 hours' duration. The patient reported as Case 7 developed a marked psychosis 2½ years after his infection and is now under treatment in a private sanitarium for mental diseases.

These rather fragmentary reports, in spite of their incompleteness, help to emphasize the fact that acute infectious myocarditis, endocarditis, and vascular disease are quite as likely to follow an acute streptococcic infection which follows a trivial injury of the hand as they are to follow the streptococcus infection associated with the acute contagious diseases, or that group of milder infections involving the upper respiratory tract which, as Carr and Walsh have recently pointed out, so frequently lead to acute infectious myocarditis.

SUMMARY

Thirty-two cases of acute spreading infection are reported, all of which developed rather rapidly after trivial injuries and in the majority of which the outstanding symptom early in the course of the infection was the presence of red lines of extension along the lymphatic channels leading upward toward the axilla.

In 2 of these cases the inflammatory process subsided rather promptly and without localization and abscess formation.

In 5 cases the symptoms at the original site of injury disappeared rather quickly, but marked axillary lymphadenitis developed and subsequently abscess formation in the axillary, supraclavicular or subpectoral regions.

In 15 cases the inflammatory process extended upward rapidly at first, then more slowly and finally came to a halt, usually at a level between the elbow and shoulder. After a varying interval the process began to recede, and eventually abscess formation took place. In the 7 cases in which the original injury was on the volar surface of the hand the abscess formation involved one or more of the synovial lined spaces (the tendon sheaths or bursæ). In 4 of 8 cases in which the original injury was on the dorsum of the hand eventual localization occurred over the dorsum of the metacarpus; in the 4 others after a varying interval of time almost the entire area of inflammatory induration over hand, forearm, and arm underwent liquefaction within a relatively brief period, with resulting abscess formation involving the subcutaneous tissues over an extensive area.

Nine patients, among them 2 physicians and 2 nurses, died after intervals of from 4 to 13 days after the original injury. One patient succumbed to a bilateral bronchopneumonia 35 days after the injury.

Of 20 cases in which bacteriological findings were available a hæmolytic streptococcus in

pure culture was recovered in 10 cases; a hæmolytic streptococcus in symbiosis with other organisms in 3 cases, a non-hæmolytic streptococcus in 4 cases, a Streptococcus viridans in 1 case, and a hæmolytic staphylococcus in 1 case.

In 5 cases definite postoperative complications developed subsequent to recovery from the acute infection; and in 4 of these the complications were attributed directly to the antecedent infection.

Of the 22 patients who recovered all were treated conservatively from the moment they were first seen, with rest in bed, massive warm wet sterile dressings over the entire upper extremity and forced administration o fluids; and in none was the inflammator process incised until absolute evidence o localization and abscess formation was pres ent.

REFERENCES

CARR, J. G., and WALSH, J. A. Acute infectious myo carditis. Illinois M. J., 1934, lxvi, 134–139.

HUDACK, S. S., and MCMASTER, P. D. The lymphati participation in human cutaneous phenomena. J Exper. Med., 1933, lvii, 751–774.

KANAVEL, ALLEN B. Infections of the Hand, 6th ed Philadelphia: Lea & Febiger, 1933.

POIRIER, P., and Cunéo, B. Étude spéciale des lympha tiques des différentes parties du corps. Chapter from Poirier and Charpy, Traité d'Anatomie humaine. Paris Masson et Cie, 1902.

THE DIEFFENBACH–WARREN OPERATION FOR CLOSURE OF THE CONGENITALLY CLEFT PALATE[1]

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THIS operation is commonly called after Bernard R. K. von Langenbeck but, as it is a fundamental contribution, it might seem fitting that it recall two men who, either simultaneously, worked out and put into execution, a successful plan for closing congenital palate clefts, that has never been superseded and, as far as known history records, was basically original.[2] There have been modifications or substitute plans, but, as a class, these are more difficult of execution and, with the exception of the "push-back" type which in this country has been developed by Dorrance, as a rule, show less regard for normal anatomical arrangement or for possible serious damage to developing bones and teeth.[3]

While hygiene of the mouth, nose, and middle ear, and the later facilitation of dental prosthetics should be sufficient reasons for the closure of the open palate cleft, the driving motive for the operation is the desire to improve the faulty speech. In its last analysis, the modifications and interruptions of the vocal sounds essential to enunciation, are just as dependent upon muscle action as is the act of walking. An inert dental prosthesis, or a repair from live extraneous or passive tissues, can be made to supplement a deficient palate, just as walking can be aided by an artificial limb, but to function, each requires that it be under some indirect muscle control.

While the common designation mentions only the cleft, such a palate is usually short anteroposteriorly and without sufficient compensating hypertrophy of its essential muscles to control the air leakage. Clinical evidence of a prevalent muscular deficiency comes from the occasional case in which there is normal speech with a wide open cleft, together with the fact that in the majority of cases, enunciation can be improved still further by speech-training subsequent to closure of the cleft. Chalmers Lyons is gathering confirmatory laboratory evidence. Judged by the relatively late period at which the average cleft palate child attempts to talk, a muscle deficiency and also the open cleft might primarily be dependent upon some derangement or blight in the nervous mechanism, just as marked congenital deficiencies of the external ear are frequently an expression of a blight somewhere in the auditory tract or its connections.

The greatest adjuvant to the short passive palate is a muscle band in the upper part of the superior pharyngeal constrictor, which can act as a half purse-string in closing off the nasopharynx. With a deficient palate, overaction of this strand may draw forward a thin, shelf-like fold of mucosa commonly called Passavant's pad and the degree to which this plica is developed before operation can be taken as a rough indication as to quality of the postoperative speech results. This necessity for developing the crippled musculature in no way minimizes the indications for proper operative closure but emphasizes the importance of not further hampering the already deficient muscle power.

Even when the operative procedure is technically correct, which presupposes preservation of an adequate blood supply, sufficient mobilization without damage to essential structures, and proper coaptation of the denuded borders, complete or partial failure may be a not uncommon result, either from lack of primary union or lack of good function. Granting all of the above, failure of union is almost always due to infection and its occurrence can be lessened chiefly by control of local foci, by having the patient in good condition, by avoiding periods of prevalent respiratory infections, or the exanthemata,

[2]The operation of bridging the cleft of the hard and soft palate by means of mucoperiosteal flaps raised from the under surface of the hard palate through lateral incisions, mobilizing the two halves of the velum by dividing the palate aponeurosis with its overlying nasal mucosa and then freshening and suturing the borders of these flaps, was first described in 1828 by Dieffenbach. In 1842, Warren reported several cases in which operation was done by the same general plan but the lateral incisions were omitted. Muetter, in 1843, reported 21 operations on the hard and soft palate, apparently using lateral incisions (1).

[3]The "push-back" operation is applicable only to partial clefts and may be indicated only when the palate is particularly short.

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Fig. 1.

Fig. 2.

Fig. 3.

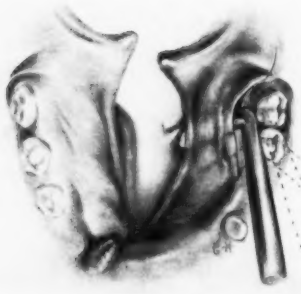

Fig. 4.

Fig. 1. A somewhat distorted representation of an average left-sided single complete cleft of the palate in which the alveolar borders have been approximated and the anterior part of the palate cleft has been narrowed by pressure of the lip and cheeks as the result of the closure of the lip cleft some months previously. The "distortion" mentioned is not of any particular structure, but in the relationship of the two component halves to each other. For the better display of the subsequent sequential steps and at the same time to accentuate the relation of each maneuver to the palate as a whole, in the above illustration each separate half of the palate and the related alveolar process, is represented as if viewed along an axis more nearly vertical to the palate process than to the palate as a whole, that is, as if each half were viewed individually. This gives an opened out appearance with greater transverse width than is normal.

Fig. 2. Mobilization—Dieffenbach's approach. As here presented, the first and the characterizing step of the Dieffenbach operation is a lateral incision through the mucoperiosteum down to the bone in the molar region, which, when extended behind the maxillary tubercle, severs the continuity between the lateral border of the soft palate and anterior faucial pillar from the buccal mucosa. The knife being held oblique to the sagittal plane, its point contacts with the alveolar bone just above the necks of the teeth. The line of the incision is along the base of the gingivæ, the fringe itself and its relation to the necks of the teeth being undisturbed. The point of the knife scratches along the bony surface of the alveolar process touching neither the necks nor crowns of the teeth and avoiding the trunk of the major palatine artery by a wide margin. All of the soft tissues down to the bone are cut as the blade is pushed backward, the line of the cut curving outward between the maxillary tubercle and the hamular process. Behind the hamular process, the axis of the knife handle shifts to more nearly parallel the sagittal plane, the blade cutting deeply in the direction of the pterygomandibular ligament, the point being kept median to the anterior border of the mandible. The exact position of this cut, both on the surface and in its depth, should be first visualized and then accurately made with one purposeful stroke.[1]

Fig. 3. Mobilization—Warren's approach. On the uncleft side where the nasal septum becomes continuous with the palate process, time and tissue will both be saved by making an incision through the septal mucosa parallel and close to its junction with the palate tissue. If the palate cleft were unduly wide in its anterior part, more of the nasal mucoperichondrium might be included in the palate flap but this is seldom necessary in single clefts and is not practicable in double clefts. The extreme anterior part of this incision is sometimes made by inserting a small blade through the nostril on the cleft side or with the cutting edge of a sharpened Brophy elevator, but, for the present, that much of the incision as here indicated will suffice.

Fig. 4. Mobilization—elevation of the mucoperiosteal flaps. The point of the angle elevator enters the lateral incision just in front of the post-palatine foramen and then by slight rotary movements of the shaft and by picking up the periosteum from the palate process, the point is worked toward the mid-plane until it pierces through the line of incision at the base of the nasal septum and protrudes into the cleft. By changing the angle at which the shaft is held, and working a bit forward, the mucoperiosteum, and, with it, the posterior palatine artery, can be freed from the underlying bone as far forward as the incisive foramen. The artery, in its course forward, may lie deeply embedded in a groove on the undersurface of the palate process, from which it is to be dislodged by working the point close to the bone.

Figs. 5, 6, and 7. Mobilization—major palatine artery. Figures 5, 6, and 7 are diagrammatic representations of a transverse section through the maxilla made just posterior to the contents of the descending palatine canal viewed from behind. Figure 5 shows the point of the elevator bit as it first enters the lateral incision near the posterior border of the hard palate. In Figure 6 the point of the elevator bit has been pushed palate-ward encountering the palate process. By rotation of the shaft, the point of the bit can be made to raise the submucous part of the artery

[1]In the original Warren operation, the elevation of the mucoperiosteal flaps is done from the cleft border, the elevator working laterally toward the base of the alveolar process. Some advocates of the Dieffenbach operation have criticized this lateral incision on the theory that it necessarily cuts essential muscles and nerves. Such a criticism can be honestly made only through a lack of understanding of its purposes and of the related anatomical structures. It not only can be made without crippling any essential structure but allows the greatest relaxation of the palate tissues with less risk to the major palatine artery and permits of subsequent fixation and hæmorrhage control, by lateral gauze packs.

Fig. 5.

Fig. 6.

Fig. 7.

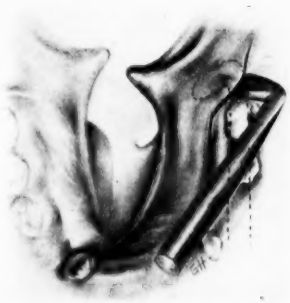

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Fig. 9.

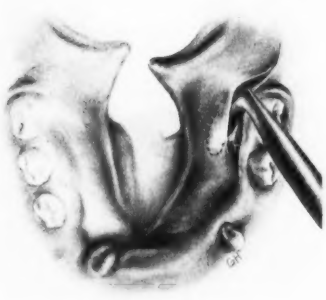


Fig. 10.

out of the posterior end of its groove. Figure 7 shows the relation of the elevator bit to the palate tissues, the artery and the bone, just as the point of the elevator bit is about to emerge into the cleft (Fig. 4).

Fig. 8. Mobilization—elevation of the mucoperiosteal flaps. Having completed the elevation of the mucoperiosteal flap from the palate process, the angle elevator is next inserted into the lateral incision between the hamular process and the maxillary tubercle, well behind the trunk of the palatine artery. The shaft is then rotated and the bit, passing behind the base of the hamular process, is pushed toward the median plane, tunneling a path that parallels and somewhat approximates the posterior border of the palate process.

Fig. 9. Mobilization—elevation of the mucoperiosteal flaps. Using the point as a fulcrum, the shaft is rotated so as to swing the heel of the instrument toward the midplane, the velum tissues being forcefully pushed in that direction.

Fig. 10. Mobilization—elevation of the mucoperiosteal flaps. The palate flap, consisting of the mucoperiosteal covering of the hard palate in front and of the velum and fauces behind, have now been fairly well freed laterally both anteriorly and posteriorly but are still bound to the alveolus by some firm tissue just median to the maxillary tubercle. This might be dissected free with a knife but more safely by stretching it with the heel of the angle elevator.

Between the posterior palatine foramen and the point at which the artery enters the substance of the mucoperiosteal covering of the palate bone for a distance of some 3 to 5 millimeters, its trunk traverses the plane between the hard and the soft tissues and lies somewhat free and enveloped in loose connective tissue. It is this anatomical arrangement that permits the palate flaps to be shifted bodily inward and still preserve the blood supply. Retaining this blood supply at least doubles the chances of a successful closure. To do this, the bit of the elevator is reinserted so that it lies just within the anterior part of the incision, its heel approximating the maxillary tubercle and the point lying along the base of the alveolus.

Fig. 11. Mobilization—elevation of the mucoperiosteal flaps. A rotation of the elevator as described under Figure 9 is now repeated. The procedure thus far depicted should be carried out on one side in a few minutes and our observations have led to the belief that speed tends greatly to lessen the essential risks of this operation. The above is likely accompanied by quite a bit of bleeding, which, if too severe, can be controlled at any stage by finger pressure with a gauze pad on the palate tissues. If, however, the main artery is not cut or torn, one can usually go through to completion and then control bleeding by packing the wound.

Fig. 12. Hæmostasis. The bleeding is now controlled by packing. This is done with a strip of gauze 4 to 6 folds thick, 2 centimeters to 2.5 centimeters wide and 3.5 to 5 centimeters long; one end is forced deep into the velar tissues, filling the posterior half of the lateral incision by means of the curved-on-the-flat elevator.

Fig. 13. Hæmostasis. About half of the strip having been disposed of as shown in Figure 12, the other end of the strip is passed under the mucoperiosteal palate flap in front of the descending palatine artery and the remaining loop of pack is stuffed into the incision external to the trunk of the artery.

Fig. 14. Mobilization—division of the palate aponeurosis. This may be done either with a curved scissors or a small sharp scalpel; the latter is the more accurate method

Fig. 11.

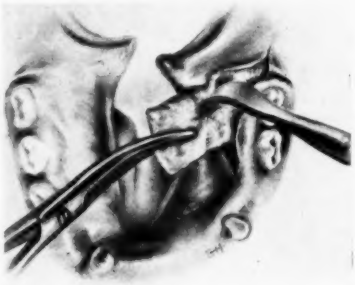


Fig. 12.

Fig. 13.

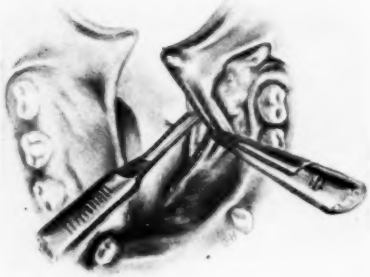


Fig. 14.

but the former may be more applicable to clefts extending but a little way forward from the velum. Inserting a sharp hook or the needle pointed puller into the free median edge of the liberated palate flap, drawing the latter toward you, the tense palate aponeurosis and the mucosa covering its nasal surface, are cut with the knife point along the posterior border of the palate process as far as one can see, which may be but a few millimeters on the first hold. Catching the palate edge farther back at each knife stroke as the flap becomes freer, more of the field continuously comes into view.

In this way one can extend the incision back to the Eustachian cushion if need be with the actual field of incision always in view. If, in the lateral pharyngeal wall, one cuts a fair-sized artery, it is caught with a heavy crushing Ochsner and, if practicable, tied with a simple ligature or suture on a curved needle. This bleeding, however, usually can be controlled after crushing the vessel, by rearranging the lateral packing so that the posterior end of the folded gauze extends into the nasopharynx just enough to rest within this lateral incision in the nasopharyngeal wall. Whether the simple cutting of the aponeurosis and nasal mucosa along the posterior border of the palate bone, gives sufficient relaxation or how far the cut must be extended along the lateral nasopharyngeal wall, is determined by repeatedly testing the relaxation with the needle pointed puller (see Fig. 17).

Fig. 15. Mobilization—division of palate aponeurosis. The elevation of the posterior part of the palate flap having been completed on one side and bleeding controlled, it is repeated on the other and the free median border of each flap is now examined. If the division of the palate from the nasal mucosa has not been completed to the posterior end of the palate process, whatever remains of this connection is divided with the point of the knife. This separation should go right to, but should not split, the velum.

Cutting the attachment of the palate aponeurosis and of the superimposed nasal mucosa along the posterior border of the palate process is the next essential step. This will complete the mobilization of the mucoperiosteal velar flap, allowing it to drop back toward the pharynx, downward toward the tongue, and median toward its fellow of the opposite side as shown in the cross section (Spalteholz).

In relatively narrow clefts, the cutting of the palate aponeurosis from the posterior border of the palate process and with it the mucosa covering its nasal surface, is sufficient. In wide clefts this incision is usually extended laterally to the nasopharyngeal wall, and backward in its mucosa toward the Eustachian, cushion, and may even include some of the fibers of the levator palati muscle before sufficient relaxation is obtained.

Fig. 16. Mobilization—division of palate aponeurosis. In partial clefts, the extensive freeing described under the preceding figure will not be necessary and it will be found more convenient to divide the aponeurosis with a curved scissors on account of the limitation of the field of vision

Fig. 17. Mobilization—testing, posteriorly. If the junction of the velum with the mucocutaneous flap can be easily brought across the midline to meet its opposite, the latter lying in its natural position, then this part of the flap is sufficiently free.

Fig. 18. Mobilization—division of the posterior faucial pillars. Reinserting the needle pointed pusher just proximal to the base of the uvula, the same test is repeated. If the posterior part of the velum is not sufficiently free, one further observes to determine if it is the resistance in the

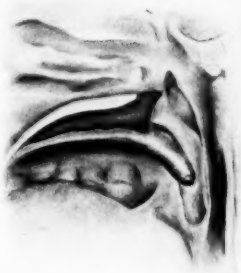
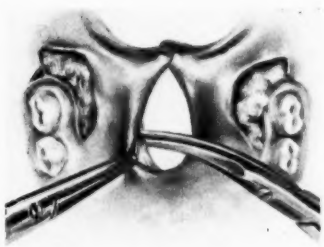


Fig. 15.



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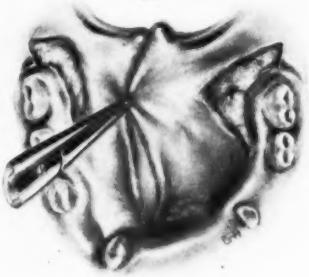


Fig. 17.

Fig. 18.

Fig. 19.

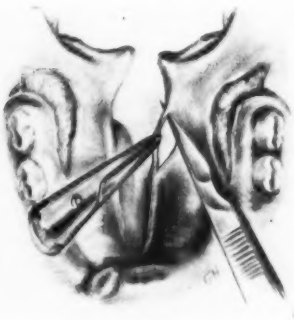


Fig. 20.

anterior or posterior pillar. The former may be released by extending the original lateral incision further backward, or, a tense posterior pillar is cut at its attachment to the pharyngeal wall with the knife or scissors, first putting it on tension with the needle pointed puller, as shown in Figure 18. If the cut is made close to the pharyngeal wall, very little of the palatopharyngeus muscle will be severed from its nerve supply and subsequent scarring will repair the defect in the pillar. Any arterial bleeding should be controlled before proceeding further and this is best done with a suture of a double plain catgut strand on a palate-shaped strong needle. The double strand will preclude loss of the needle in the tissues, should struggling occur at the time of its insertion. If, so far, things have gone well and the child is in good condition, one may proceed to free the mucoperiosteal flaps at the anterior end of the cleft. To facilitate the suturing in this part, this freeing should extend to the edge of the gum or to the incisor gum fringe and a short, somewhat transverse cut on each side, vertical to the cleft, may be of great help. (See Fig. 19.)

Fig. 19. Mobilization—elevation of mucoperiosteal flap. Usually this is most easily accomplished with a sharp edged Brophy elevator with which one can divide the connection between the palate and the nasal mucosa and also raise the flap from the underlying bone. In freeing the median edge of the flap that covers the premaxilla, difficulty is encountered in the neighborhood of the incisive foramen. It may be of some help to insert the small knife through the nostril or to use the curved-on-the-flat elevator. We have ceased to do a palate repair on children under a year old, and by that time the incisor teeth are usually erupted, but it is to be remembered in using the Brophy elevator in this region that, if the mucoperiosteum is raised from over the bud of an erupting tooth, it may interfere with its further development.[1] If, however, after freeing the flaps at their nasopharyngeal attachments, there is a tendency for bleeding to persist, or if there is any other suggestion that it might be well to curtail the operation, one may now advantageously disregard the anterior part of the cleft and proceed at once to denude and suture the posterior part that has already been mobilized. After this suturing has been completed, the anterior part of the cleft may then be sutured or it may be deferred to some future time as the patient's condition dictates. Also, if either major palatine artery has been damaged, one should be very cautious about cutting around the anterior end of the flap of the damaged side as some necessary blood supply or return might in this way be sacrificed.

Fig. 20. Denudation—of the cleft border by paring. The classic plan of freshening the cleft borders of the velum and uvula for suture is to cut off a thin ribbon of mucosa, but this is ordinarily an unnecessary sacrifice of tissue in an area already deficient, and we now resort to it only under one of three conditions: (a) when there is some reason to complete the operation in the shortest possible time; (b) when there is some special difficulty in getting at the field of operation; (c) in cases of two stage or secondary operation after a previous failure where the cleft borders are puckered with hard scar.

[1]Logan has shown that the buds of the premolar teeth lie in the soft tissues of the palate just mesial to deciduous molars where they might be damaged easily either by injudicious use of the knife or elevator.

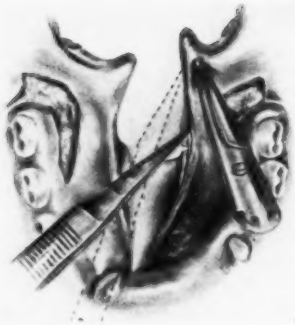
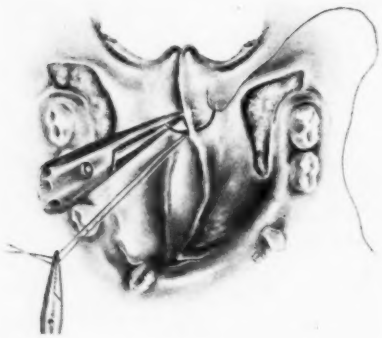


Fig. 21.

Fig. 22.

Fig. 23.



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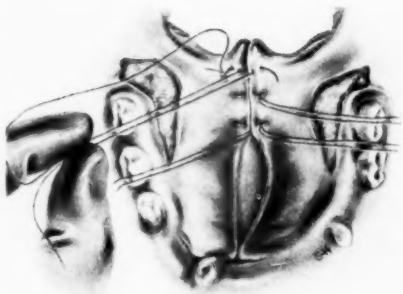


Fig. 25.

Fig. 21. Denudation—of the cleft borders by splitting. In a primary operation, where the velum is accessible and where conditions are satisfactory, we follow the plan, used by Lyons, of splitting the mucosa of the border of the velum and uvula, and also of the posterior pillars if these latter are to be united (see Fig. 22).

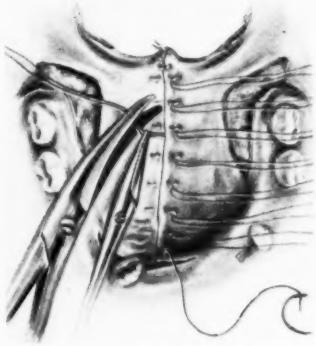
The border of the velum is split deep enough to allow sufficient eversion of the edges to give a raw surface equal to its thickness. The cut will be a little deeper anteriorly than in the center and only the mucosa is divided at the uvula. The under surface of the base of the uvula is caught with the pusher as shown, or the base of the velum is engaged with the puller and the free border is split with a bistoury or a special knife. In this way the depth of the cut can be judged and controlled with considerable accuracy. As one cuts farther back, the pusher can be substituted for the puller. When things go nicely, this cut may be completed with one movement, the knife gradually paralleling the tense border of the velum and smoothly slitting the mucosa as it is pushed back toward the apex of the uvula. On the other hand, it may prove to be a "catch-as-catch-can" performance, and one transfixes the velum to push or pull in any way that best serves.

Whether done by paring or slitting, both borders are examined throughout their full extent to see that everywhere they present sufficiently broad, cleanly cut, raw surfaces which can be easily approximated by the sutures. Much time will be lost and union may be compromised by attempting to unite ill-fitting parts. Any place in the velum where the mucous edge is rough or unmanageable can be judiciously undercut or pared. The area near the palate aponeurosis is particularly important. The borders of the mucoperiosteal flaps from the hard palate should first be examined with the rounded point of an artery forceps, for any spicules of bone that might have been included with the flap and any such should be removed. Next, any ragged edges should be trimmed and one should be able to evert the edge of the flap toward the mouth even in its anterior extremity.

Fig. 22. Denudation—splitting the posterior faucial pillars. In those past infancy, the palate can often be conveniently lengthened by continuing the denudation and the suturing to the adjacent parts of the posterior faucial pillars. To do this the anterior half of the border of each is split as shown, this cut being continuous with the velar slit at the base of the uvula, and farther back with the transverse cut in the body of the pillar. It is possible to unite the pillars sufficiently to interfere immediately or subsequently with nasal respiration and this must be borne in mind. Figure 29 shows pillars sutured. When this is done suturing of the nasal surface shown in Figure 28 is omitted.

Fig. 23. Suturing—the key suture. The first suture which, with us, substitutes for any form of supplementary fixation, engages the fibers of the palate aponeurosis on each side. This being of tough fibrous tissue, a mild infection, or drawing the suture too tightly, will not cause it to cut through as quickly as in the softer structures. This type of stay suture is not as apt to do harm as are lead plates or circumferential tape, bands, or any other type of surface pressure.

Fig. 26.



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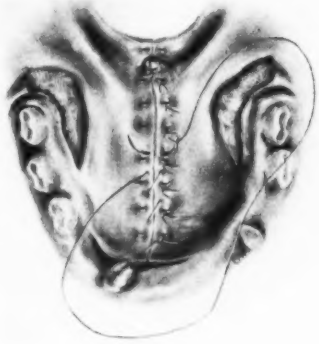

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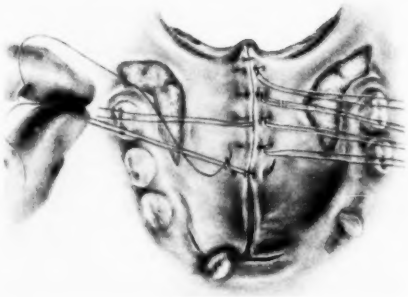

Fig. 27.

The left border of the cleft is drawn forward with the puller and the point of a full curved needle enters the raw surface near the oral border at the cut edge of the aponeurosis, digging 4 or 5 millimeters into the substance of the velum to emerge posteriorly nearer the nasopharyngeal border. The right border is then caught with the puller and the needle entering posteriorly near the oral border emerges near the nasopharyngeal border. The knot is tied at the nasopharyngeal surface. Both strands are caught with a light artery forceps (mosquito pattern) 10 or 12 centimeters from the knot and dropped to the left of the patient's face. (See Fig. 24.)

Fig. 24. Suturing—the velum. Starting just behind this first, the aponeurotic suture (5), three or four interrupted vertical mattress sutures are placed in the velum and the mucous edge on each side is in turn caught up with the pusher so that the needle will engage just 1 or 2 millimeters of the edge.[1]

[1]For sutures we use a good quality of "live" horse hair both because it causes very little irritation and is, therefore, well tolerated by the tissues, and also, though it has sufficient strength to stand proper handling, it is apt to break if the knots are drawn too tightly. Each is cut 15 to 18 inches long, threaded at the proximal, the thicker end of the hair, tied in the eye with a single knot, and the protruding short end is cut half the length of the needle. There are microscopic scales on a horse hair, their free end directed distally, which make it easier to draw the hair through the tissues root-end first. If the hair is too long or too short, it will slow up the knotting. If the short end protrudes too far from the eye it will be in the way; if it is too short it may untie itself. Horse hair becomes untied easily and for this reason at least four knots are put on each suture as follows: the first with just sufficient tension to approximate the raw surfaces closely, the second so as not to disturb the tension of the first; the next two knots are tied with increasing tension so as to prevent untying.

Fig. 25. Suturing—the velum. Then drawing on this loop with the thumb and finger, the needle traverses both borders deeply, but not deep enough to include any of the mucosa of the pharyngeal surface. Each of these three or four deep sutures, as they are tied, are caught with forceps and dropped to the right of the patient's face. One or two simple mucosa sutures are placed on the under surface of the uvula and one in its tip, the free ends of these sutures with the attached forceps being dropped in front of the patient's face. This brings the pharyngeal surface of the uvula and of the velum into view (Fig. 26).

Fig. 26. Suturing—the uvula and upper surface of the velum. One or two mucosa sutures are placed in the pharyngeal surface of the uvula and, if the posterior faucial pillars are not to be united, two or three vertical mattress sutures along the upper surface of the velum.

Fig. 27. Suturing—the mucoperiosteal flaps. If needed, the anterior end of the cleft border is now further mobilized. If the artery was damaged on one side, one might get by with extending the lateral incision on the sound side all the way forward until it connects with the cleft in front, thus liberating a tongue-shaped flap with its base at the major palatine artery, which can then be united to the other side with expectation of primary union. Where both descending palatine arteries are intact, one might raise such a tongue-shaped flap on either side and, after uniting along the cleft line, anchor the anterior free end where convenient, with a few simple "tacking" sutures. This is mentioned by Arthur Keith (6), who simply allows the freed flap to hang loose trusting to granulation and scarring to anchor the flap in its proper place to the under surface of the maxilla. With the addition of the "tacking" sutures, this has worked satisfactorily in our hands, but we prefer, where possible, to leave, at least, a narrow attachment of uncut tissues anteriorly on one side. On the whole, however, if there is any doubt of the integrity of the major palatine arteries, it is safer to suture as far forward as the original relaxation will permit without tension and do the remainder at a subsequent operation as a simple failure of union is much less a catastrophe than a slough or a distorted flap.

The mucoperiosteal palate flaps are united with vertical mattress sutures bringing several millimeters of the raw upper surfaces into contact. It is at the junction of the velum with the mucoperiosteal flaps that one is most apt to have a failure of union due either to insufficient relaxation or deficient blood supply and it is to be remembered that tight suturing interferes with blood supply.

and, especially with young infants, by carefully protecting the patient from contamination carried by the operator's breath or from the presence of someone with an acute coryza. That aseptic or antiseptic technique, as ordinarily interpreted, may have little bearing on the result, is suggested by pre-Listerian reports of series operated upon with fewer average failures than we can show today (Muetter's series). Of importance, is careful handling of the tissues and of the patient, the prevention of excessive loss of blood, and of aspiration. The latter is greatly helped by operating with the patient's head hanging over the end of the table (the Rose position) and by suction. It is our belief that there is no postoperative plan of mechanical protection or support of the suture line equal to packing of the lateral incision with strips of gauze. This also helps to control bleeding and splints the palate, but the use of any one of these is not free from added danger, either to the patient or the palate.

The most pertinent criticism that can be leveled at the original Dieffenbach-Warren operation is that it fails permanently to lengthen the intrinsically short palate. Brophy attempted to compensate for this by partially uniting the posterior faucial pillars and on the average, produced the longest palates that we have had opportunity to examine. However the posterior part of a palate thus lengthened curves somewhat downward away from the plane of the pharyngeal muscular band mentioned, and thus, must work at a mechanical disadvantage. To be of the greatest help, the lengthening should be in the plane of Passavant's pad. When at the operation the velum is allowed to drop back by section of the palate aponeurosis, a raw area presents itself on the upper surface of the palate flap appearing from under the posterior border of the hard palate (see Fig. 15). As this heals, the velum again assumes its original position. We have attempted to prevent the secondary drawing forward of the velum by covering this raw area with flaps of mucosa turned from the cheek through the lateral incisions. This has given us some quite satisfactory results but, on the average, the bleeding has been so severe as to cast a doubt on the advisability of the procedure. Veau has varied the original procedure by not cutting the nasal mucosa laterally behind the bony palate, but undermining and stretching it without dividing the aponeurosis. The thought occurs that the indications which time may confirm for the more radical "push-back" modification will come, not simply from the fact that it lengthens the palate, but that the lengthening is in

Fig. 28. Suturing—mucoperiosteal flaps. The most anterior suture is tied with a long strand attached to the needle which latter is temporarily dropped in front of the patient's face.

Returning to the aponeurotic suture that hangs to the patient's left, both strands are caught in the tip of a pointed artery forceps 2 centimeters from the knot, and the suture is cut just beyond. The beak of the locked forcep is then pushed into the nasopharynx, the jaws are opened to liberate the strands and the forceps is withdrawn, the suture remaining on the pharyngeal surface later to cut its way out. The exact circumstances of its subsequent expulsion we do not know for we have never again heard from a single one of them. One could use chromic gut, but the knot would still be thrown off and the gut would cause more tissue reaction than the hair, in a place where the quickest possible union with the least disturbance is most desirable. If needed, an extra suture is added on the under surface.

Fig. 29. Suturing—approximating the mucosa. The needle carrying the anterior suture is again picked up and the mucous edges are accurately coapted all the way back to the base of the uvula with a light running suture which is cut 1 centimeter beyond the last catch without knotting. The posterior pillars are shown to have been united.

A careful inspection of the suture line, for bleeding, and of the position of the packs, completes the operation.

Operation for a partial cleft is done on the same general plan except that where the cleft is very narrow and extends only a little way into the hard palate, a special aponeurotic suture is not necessary. One could conveniently close the velar clefts without making the lateral incision, the original Warren operation, by elevating the mucoperiosteum from the cleft with a Brophy elevator, but the palate aponeurosis should always be severed from the posterior border of the palate process and packing, inserted through the lateral incisions, is a comforting prophylactic against bleeding. Furthermore, if, as far as possible, one sticks to a basic plan of operation, he will develop a better personal technique and better team work than if he yields to the temptation of making unnecessary variations.

Fig. 30. Secondary operation. a, A case in which there had been practically no closure of the cleft from previous operations, but a complete loss of the right mucoperiosteal flap and a very much shortened velum. The rough area in front of *B* indicates the palate process covered only by unusable scar. The dotted lines indicate a flap to be raised from the cheek to replace the right mucoperiosteal flap. b, The cheek flap has been raised and, on the left side, a dotted line indicates the line of incision for splitting the cleft border and the posterior pillar. c, The cheek flap has been sutured into position to form the right half of the palate anteriorly and the two halves of the velum.

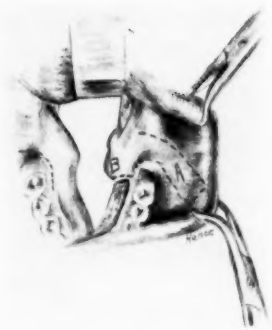

Fig. 30, a.

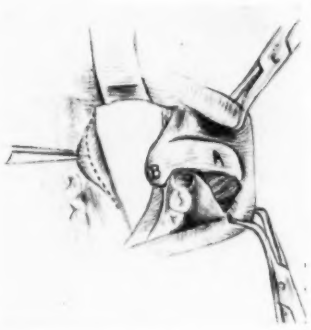

Fig. 30, b.

Fig. 30, c.

Fig. 31, a.

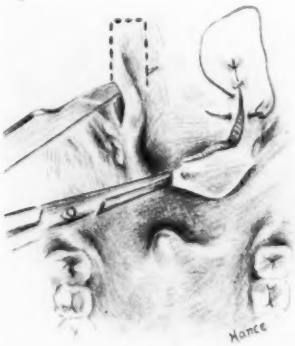

Fig. 31, b.

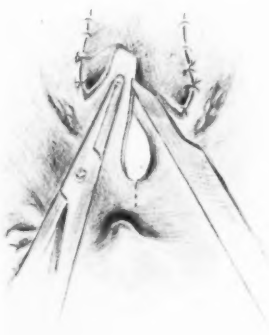

Fig. 31, c.

Fig. 31. Secondary operation. a, Examination showed patient had had a flap turned from the right cheek to fill in the space between first molar and central incisor, going back to the base of the first molar on the left side. There is union everywhere with the exception of two places, one to the right anteriorly, and one to the left posteriorly. The uvula lies between the molars. Posterior pillars had been brought together for 1 centimeter behind the uvula, but the opening between the nasal and oral pharynx is 23 millimeters from before backward and at the posterior pharyngeal wall is the same distance from side to side. He has some action of the pharyngeal muscles.

b, Palate was lengthened by freeing the posterior pillars from their attachment to the pharynx almost to the upper pole of the tonsil; then the free border of each pillar was split and the median borders were united (Fig. 31c). This accomplished two things: it released the pillars so that the fauces and velum could be drawn up to the proper level, and it allowed lengthening of the velum until it practically touched the posterior wall of the pharynx (Fig. 31d).

e, The palate has been reconstructed so as to extend 3.5 centimeters behind the uvula. There is an opening between the nasopharynx and oral pharynx 0.5 centimeter from before backward and 1 centimeter from side to side. The speech is good. He still has one opening in the upper fornix mesial of the flap that has been turned in from the cheek, and another small opening lateral of this flap in the anterior part of palate, but these seem to cause no inconvenience.

Fig. 31, d.

Fig. 31, e.

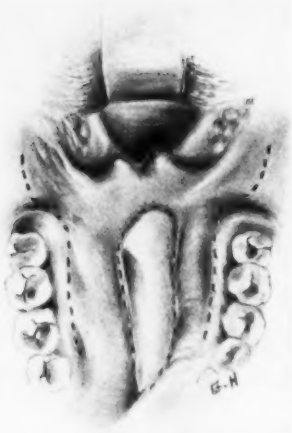

Fig. 32, a.

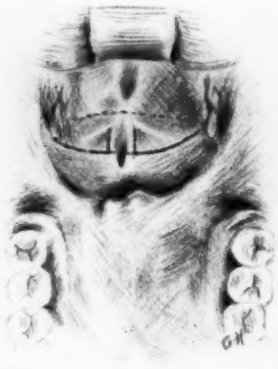

Fig. 32, b.

Fig. 32, c.

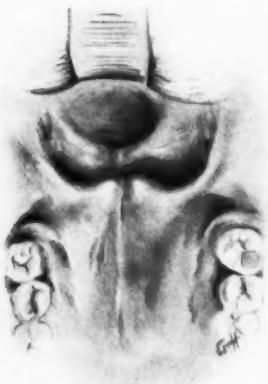

Fig. 32, d.

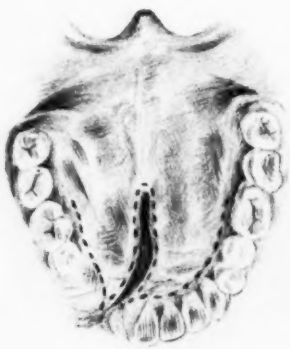

Fig. 33, a.

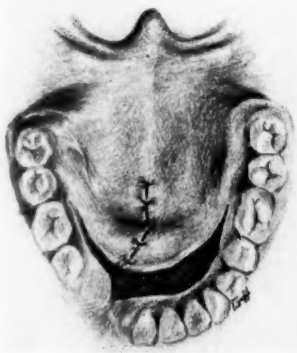

Fig. 33, b.

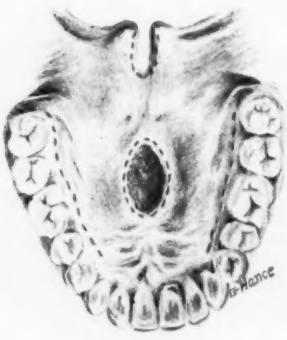

Fig. 34, a.

Fig. 34, b.

Fig. 32. Secondary operation. a, The patient originally had a double cleft of the lip and palate. At operation there were 40 millimeters of available flap material, about a 35 millimeter space to fill in and the posterior pillars were free and well developed.

The denuding and relaxing are indicated in Fig. 31.

The second step was similar to that shown in Fig. 31, b and c, but, because we drew too freely on the pharyngeal mucosa, a constriction of the nasopharyngeal opening later developed (see Fig. 32, b). The very small opening between the nasopharynx and the oral pharynx was enlarged by a transverse incision through the oral mucosa at about the level of the upper pole of the tonsils. The mucous mem-

Fig. 35, a.

Fig. 35, b.

ne was raised by dissecting it backward for a short tance and at this level cutting through the nasal mucous mbrane, thus forming two flaps, one with the base below i one with the base above, the one below being com- ed of oral, and the one above of nasal, mucous mem- ne. These flaps were curled on themselves and sutured h interrupted chromic catgut so that the entire naso- aryngeal opening was surrounded with mucous mem- ne. In this way the opening was considerably enlarged e Fig. 32, c).

l, Final result 7 months following last operation.

Fig. 33. Secondary operation. a, Patient had had von ngenback operation. Figure 33, a shows horse-shoe inci- n running around just inside the fringe, from the first olar on the left to almost the second premolar on the ght. Dissected flaps back, freshened the edges of the cleft nd sutured them together, leaving the anterior part of the flaps free (6). (See Fig. 33, b).

Fig. 34. Secondary operation. a, Small defect in central portion of palate is closed by freely undermining through lateral incisions shown and if the defect is anywhere near the posterior border of the hard palate, this must be cut. The borders of the opening are then freshened and sutured as in the first operation. It is seldom necessary to close a bifid uvula, but to save nervousness on the part of the mother, it can be closed as shown in this case (Fig. 34, b).

Fig. 35. Secondary operation. a, In palates distorted by previous operation, one must adapt the plan to meet conditions. The right half of the uvula was united to the left border of the pillar, in this case. The dotted lines indicate the denudation slit placed slightly to the pharyngeal and nasal surface.

b, Shows the suturing of the uvula and pillars, which gave a fairly long velum. The mobilization incisions, as they scar up, will draw the new velum still farther back.

Fig. 36. Closing the double cleft. Considerable difficulty has frequently been encountered in closing the anterior end of a wide open palate cleft. Figure 36—A, B, C, and D illustrate the plan by which we have been able to obviate most of this difficulty. It is usually done as the second step, after the lip has been closed. The *A* flaps are raised from the septum and the sides of the sides of the premaxilla with base above. The *B* flaps are tongue-shaped with base posterior and contain the major palatine artery. After mobilizing the *A* flaps, a section is removed from the septum *X* which permits the premaxilla to move backward in contact with but not in between the maxillæ. The cleft was closed by rotating the *A* flap laterally and superimposing the *B* flap, raw surface to raw surface, and uniting the 3 mattress sutures. The premaxilla is mobilized, pushed backward, and held there by raising and uniting the mucous membrane across the face of the alveolar cleft. A year or so later the posterior part of the cleft is closed.

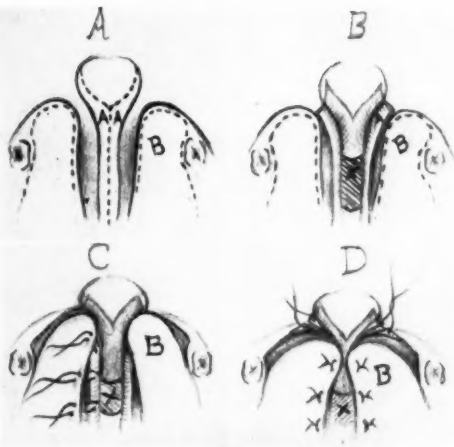

Fig. 36.

the plane of the constricting pharyngeal muscle band.

The basic factor for success or failure and which largely determines operability is the proportion of usable tissue to the width of the area to be bridged over. At the alveolar border, spare palate tissue is practically nil, so that here it is necessary directly to approximate the bones. This is most easily, safely, and accurately accomplished by pressure of

the lip after repair of the lip cleft (4). In the molar region the proportion of available mucoperiosteal flaps increases with the development of the unerupted teeth, so that in most instances conditions for closure will become satisfactory between 1 and 2 years of age (2) (see Fig. 30). In rare instances where the cleft ends anteriorly in a rounded opening bounded by the alveolus and with little or no palate process (see Fig. 16), the operation may have to be postponed for some time and even then some modification of the classic procedure may be necessary.

In older people, especially those in whom the soft tissues have been subjected to the pressure of a dental plate which was, heretofore, retained by tooth clasps, in palates damaged by previous operation or in extremely wide clefts, the closure can be made possible or more certain by dividing the operation into two steps, first raising and packing under the flaps, and, in a few days to 2 weeks, after reaction subsides, freshening the borders and suturing (3).

One strong recommendation for the classi Dieffenbach-Warren operation is that if don without injuring the major palatine arterie and the flaps should fail to unite at the sutur line, there will be little visible loss of tissu and the flaps will drop back to a normal posi tion, without embarrassment to a properly timed subsequent attempt.

This article is presented not with the idea that we have anything new to offer, but, perhaps, as a timely review of underlying principles of a usable technique.

REFERENCES

1. Blair, V. P. Congenital facial clefts. Surg., Gynec. & Obst., 1923, xxxvii, 530–533.
2. Idem. The treatment of cleft palate and harelip in early infancy. Internat. Clin., 1916, iv, Series 26, p. 211.
3. Idem. Surgery and Diseases of the Mouth and Jaws. 3d ed., pp. 217 and 211. St. Louis: C. V. Mosby Company, 1917.
4. Blair, V. P., and Brown, J. B. Mirault operation for single harelip. Surg., Gynec. & Obst., 1930, li, 81–98.
5. Davis, J. S. Vertical mattress suture. Ann. Surg., 1933, xcviii, 941–951.
6. Keith, Arthur. Brit. M. J., 1909, Aug. 7, pp. 310, 363 and 438.

HYDATID DISEASE OF THE BRAIN

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AS in the case of all organs, infestation of the brain with echinococcal disease may be either primary or secondary. the former the cysts are derived from hexa- nt embryos which, after passage through the er and lungs, have been carried by the ca- id arterial stream to the brain. Secondary sts are metastatic and result from the sow- g by the blood stream of scolices, derived m a fertile primary simple cyst which has ptured into the left side of the heart. It is vious, although the fact has not been uni- rsally recognized, that the pathological and nical aspects of these two types are very fferent and until this is appreciated, much nfusion must occur in their interpretation.

PRIMARY CYSTS

Even in countries like Australia and Argen- na, where hydatid disease is relatively com- non, primary cerebral hydatid cysts are quite rare. Statistical studies bring out the inter- esting fact that they are at least seven times as frequently met with in the child as in the adult—the relative figures being 4.9 per cent and 0.7 per cent. This is explained by the fact that infestation with hydatid disease as with other helminthic diseases almost invariably occurs in early life—the period of disregard for cleanliness and personal hygiene and the age of close contact with dogs. Although the greater number (88 per cent) of ingested embryos are held up in the capillary beds of the liver or lung, the remainder pass through and are available for distribution to other organs by the blood stream. There seems no doubt that the peripheral distribution of hydatid disease is entirely dependent on the vagaries of the systemic arterial circulation. Owing to the comparatively large size of the carotid vessels in the child, a fair proportion of embryos must be carried to the brain, where encystment with the formation of a single univesicular cyst usually occurs. As a cyst in this situation grows relatively rapidly, because of the soft, non-resistant tissue and the ample blood supply, pressure effects on the brain manifest themselves within a few years, so that the child develops signs of intracranial pressure and eventually undergoes an operation or dies; thus adult life is rarely, if ever, reached with an intact primary cyst.

As in the case with hydatid disease of practically all organs, the liver, as the first filter, also often contains a primary cyst of the same age, so that the association of hepatic and cerebral cysts is found in approximately 80 per cent of these cases.

Pathology. Primary cysts are nearly always single; any case showing multiple cysts should at once be suspected and the possibility of the cysts being secondary considered. They are typically univesicular, daughter cyst formation being of extreme rarity and in the few cases in which it has been recorded, has been associated with a history of local trauma to the cranium. The cyst commences its growth in the cerebral substance, quietly enlarging until it is big enough to produce pressure effects. Here again the location seems more or less to coincide with the distribution of the blood vessels—the frontal lobe being the most frequent site. As the cyst grows it may impinge on the lateral ventricle, on the surface, or even erode the skull, and rupture in any of these directions may occur, usually with profound anaphylactic symptoms and death. The adventitious capsule laid down by the cerebral tissues is ill defined and at times almost nonexistent—a fact well in keeping with the nonreactive nature of the glial tissue generally. Adhesions between the meningeal layers may occur as the result of pressure but most of the vague microscopical changes which have been described by some observers as occurring around these cysts seem to have been produced as a result of terminal phenomena.

The nervous tissues are simply pushed aside and even in large cysts it is surprising how little alteration occurs in their structure. The

Fig. 1. Univesicular hydatid cyst of occipital lobe of the brain from a child aged 12. From the Pathological Museum, University of Sydney.

size to which the cyst can grow and yet be compatible with life is astonishing—cases in children in which more than 20 ounces of fluid were found have been recorded (Fig. 1). This is due to the yielding nature of the skull which prevails during the actively growing period and to the remarkable compensatory powers of brain tissue, particularly in young people.

The blood supply of the brain is so ample and the soft nervous tissue so non-resistant that growth is regular and comparatively rapid, while in nearly all cases the cyst is healthy and fertile, containing many scolices within their brood capsules. Degeneration, with the production of pultaceous material containing cholesterin and hyaline débris does occur sometimes, but no cases of dense fibrosis or calcification have been recorded. Pressure effects may be manifested by distortion or thinning of the skull, either generally or in a localized area, and some remarkable cases have been reported. Pressure on the ventricular system with the production of varying degrees of internal hydrocephalus or ventricular distortion with the production of rapid increase of intracranial pressure is common. Finally, localized pressure on certain non-silent areas of the brain may produce—as in the case of other non-infiltrating tumors—typical clinical syndromes.

Clinical aspects. The average age of incidence in the recorded Australian cases is 11 years, and this corresponds with statistics from South America. The latency of the disease is remarkable and with the exception of the cystic astrocytomata is greater than that of any other intracranial tumor. As is to be expected, the symptomatology is that of a simple non-infiltrating, slowly growing tumor of a cerebral hemisphere and depends on the location of the cyst. General symptoms predominate, and, except in a country where hydatid disease is well known, the true pathological nature of the lesion usually remains unsuspected. Thinning of the skull which may be reduced to the thinness of paper or even perforated, may be detected over the cyst, either by palpation or radiography. This contrasts with the hyperostosis of meningeal or osseous neoplasms and is extremely suggestive. Localized tenderness or a "cracked pot" sound on percussion may also be present.

It follows that the diagnosis in any of these cases will depend on a full neurological examination; if necessary, the standard ancillary methods of examination which are found so necessary in the localization of many intracranial tumors being used. As in these cases the all important accuracy in localization depends on a very careful analysis of signs and symptoms, but it should be possible in the majority of cases. An accurate pathological diagnosis will, except in so called "hydatid countries" be rarely made.

It would be expected on *a priori* grounds that the Casoni intradermal test would be positive in a high percentage of these cases but in the few recorded cases in which the test has been carried out, the reaction has been negative or equivocal. Further statistics are urgently required to determine the diagnostic value of this test in intracranial hydatic disease. As in the case of simple cysts generally, the specific hydatid complement fixation test will be of little, if any, value.

The following case history illustrates some of the features mentioned:

CASE 1. D.P., male, aged 13 years, was admitted to the Royal Alexandra Hospital for Children complaining that for the preceding 8 months he had suffered from severe headache which was made worse by exertion or excitement. He had vomited on many occasions, the event having no relationship to the taking of food, but neither the headache nor the vomiting had increased in frequency or intensity. For the 6 months before admission he had noticed that he could not see the blackboard at school plainly, but he had never had double vision. Further questioning elicited the fact that he had a tendency to become giddy on stooping and that recently he had had some tingling and numbness in both hands. He had had no serious illness and complained of little except the headache. He had spent all his life on a farm.

Examination revealed a well developed lad—normal for his age in all respects—bright and intelligent in his answers. His head was normal to palpation but measured a little more than normal although there was no suspicion of internal hydrocephalus. There was no tenderness to percussion and no "cracked pot" sound. Examination of the eye grounds showed equal bilateral papillœdema of approximately 2 diopters; the visual acuity was somewhat below normal, but the fields of vision were normal to both small and large objects. The pupils were equal and reacted to light while there was no nystagmus. Examination of all the cranial nerves was entirely negative, while all the peripheral reflexes were equal and active.

Investigation of the appreciation of various sensations in the limbs showed no abnormality.

The gait was not abnormal, nor was there any ataxia or signs of cerebellar involvement.

Radiography revealed a slight increase of convolutional markings, some questionable separation of the coronal sutures but no bony abnormality of any sort. The Casoni intradermal reaction and the hydatid complement fixation test were both negative.

In view of the lack of any local or even lateralizing signs, and because intracranial tumor was suspected, it was decided to perform ventricular estimation. This was carried out under local anæsthesia through two symmetrically placed posterior openings. The right lateral ventricle was struck at a depth of 4.5 centimeters but seemed to be somewhat displaced laterally, while the fluid seemed under normal pressure. The left needle struck fluid at a depth of 2 centimeters and this was under a much higher pressure than the right. The asymmetry of the ventricles showed that the lesion was not a centrally placed one and in view of the equivocal findings, the head was rocked from side to side and air allowed to enter in to both needles in turn, in order to obtain a ventriculogram. It was at once suggested that the left sided collection might be an hydatid cyst and although no hooklets or scolices were found in the fluid, it had a much higher content of sodium chloride than that of the normal ventricle—an important diagnostic point.

The subsequent series of radiographs (Figs. 2 and 3) showed a spherical cyst about 4 inches in diameter, deeply placed in the left occipital lobe, obliterating the posterior horn of the left lateral ventricle, but not communicating with it. The posterior horn of the right side was somewhat displaced to the right. Across the cyst cavity were several trabeculæ, which gave the impression of multiloculation.

This appearance was so suggestive that, taken into account with the extreme latency of the lesion, the age of the patient, and the rarity of other cystic tumors in this region, it led to the tentative diagnosis of hydatid cyst, and operation was advised.

This was carried out, under local anæsthesia, through a posteriorly placed osteoplastic flap based on the left temporal muscle. When the dura was opened the brain bulged a little and the cyst was tapped, a little brownish fluid being obtained. After due precautions as to soiling of the field, the cortex was excised with the Bovie knife to a depth of 3 centimeters and the air bubble in the top of the cyst opened into without any difficulty. In view of the close contact with the ventricle, no formalin was used as a sterilizing medium. The fluid was sucked out and the collapsed laminated membrane which had produced the peculiar trabeculation on the radiogram was easily coaxed out in its entirety, still containing some fluid. The cavity was then sucked completely dry and the thin ependymal wall of the lateral ventricle, with its characteristic pulsation, was seen lying bare on the medial wall. Using plenty of Ringer's solution and "lintene" pledgets, the toilet of the cavity was completed, and a little alcohol on cotton wool was used to swab the bottom of the cavity, which, after further flushing and drying, was filled with Ringer's solution. The degree of collapse of the hemisphere after evacuation of the cyst was remarkable. The dura and scalp wound were sutured in the ordinary way without any drainage. The patient was returned to the ward in excellent condition, was propped up after a few hours, and made an uneventful recovery. Examination of the fluid and the cyst revealed very few scolices, but a few hooklets, so that it is probable that the risk of contamination of the area with hydatid elements was negligible.

The cyst, which was well over 10 centimeters in diameter was lying deeply in the occipital region but had produced no interference with the fibers of the optic radiation as it was too far forward and too cranial. Neither had it produced any motor or sensory phenomena, owing to its posterior position, and it is certain that had it not been for the performance of bilateral ventricular puncture, which permitted air entry, localization would have been impossible. The laminated membrane of the cyst was only separated from the

Fig. 2. Case 1. Ventriculogram showing hydatid cyst containing air and some distortion and displacement of ventricular system. Antero-posterior view.

lateral ventricle by the thin ependymal lining of the latter, so that the patient was in imminent danger of an intraventricular rupture, an event which is almost certainly fatal. It is, indeed, rather remarkable that the exploratory puncture did not, as it does occasionally in cases of pulmonary cysts, precipitate rupture, owing to the sudden liberation of support from the ventricular wall.

The following is an example of hydatid of the cerebellum. This is the rarest location for primary hydatid disease—only two undoubted cases having been previously recorded, both in South America, by Pflaumer and Chiappori. Morquio has recorded a hydatid cyst of the cerebellopontine angle. For this case history I am indebted to Dr. E. Britten-Jones of Adelaide, South Australia.

CASE 2. M.H., a boy aged 3 years 9 months, who had lived all his life on a farm in the country, was admitted to the Adelaide Hospital giving a history of 5 weeks' intermittent vomiting. These attacks came on once or twice a week and were associated with listlessness and drowsiness—between the attacks he was bright and active. The parents had never noticed any unsteadiness of gait, nor was there any history of falling.

Fig. 3. Case 1. Ventriculogram. Lateral view.

On examination, the patient looked ill, lay curled up on his right side with his head retracted, and periodically he uttered a peculiar cat-like cry. His temperature was normal and his pulse rate varied from 80 to 100 beats per minute, showing sinus arrhythmia. There was a paralysis of the right external rectus muscle. The superficial abdominal and cremasteric reflexes were equal and active—the deep reflexes showed no abnormality. Double Kernig's sign was present. A radiogram showed no local thinning of the skull and was regarded as completely negative. He was thought to be suffering from basal meningitis and died suddenly 2 days after admission, following lumbar puncture.

Autopsy revealed a small hydatid cyst about 1.5 centimeters in diameter in the right lobe of the liver and the left lateral lobe of the cerebellum was occupied by a subcortical cyst, approximately 2.5 centimeters in diameter, which had produced internal hydrocephalus and a definite pressure cone. The latter cyst was univesicular, thin walled, contained scolices, and had extended to the arachnoid which was so thin over it that at autopsy the cyst fell away. There is no doubt that the hepatic and cerebellar cysts were both primary and both of the same age—the difference in size being due to the more rapid growth in the vascular and non-resistant tissue of the cerebellum. The meningitic phenomena are of interest and are perhaps due to actual stretching and irritation of the arachnoid over it. I have noticed similar phenomena in a rapidly growing neoplasm which had extended into the cerebellar meninges.

The following case, for the record of which I am indebted to Mr. W. A. Hailes, F.R.C.S.

of Melbourne, is a good example of what is probably—in the absence of the certainty of complete autopsy—a primary cerebral hydatid cyst in the adult.

CASE 3. M.R., a female aged 44 years, was admitted to the Melbourne Hospital with a history of severe frontal headache of 6 months' duration. The headaches which were at first paroxysmal, became progressively worse and more persistent, particularly during the 3 months previous to admission. For the last 2 months her memory had begun to fail, while her responses to questions became uncertain and she exhibited a certain degree of aphasia at times. Three weeks before admission her mother noticed that her speech was slurred, her writing began to deteriorate, while a progressive weakness in the right arm and leg developed, so that she could neither feed herself nor walk without assistance.

There was no vomiting and no gross interference with vision, although she thought that the latter was not so good as formerly. Neither was there any history of hallucinations of smell or sight.

On examination, there were found no signs of disease in the thoracic or abdominal regions. The head showed no abnormality—on inspection or palpation. There was no ocular palsy, but there was a slight sided facial paralysis of the upper motor neurone type. The hearing appeared to be hyperacute, and there was some difficulty in swallowing, although the palate moved normally on both sides. The optic discs showed venous congestion and a doubtful degree of papillœdema. Owing to lack of co-operation and concentration it was found impossible to determine the fields of vision.

The superficial abdominal reflexes were present on both sides but the left was much more active than the right. All the deep reflexes of the right side were much more active than those of the left, but there was no clonus and plantar stimulation gave a flexor response on both sides. There were no signs suggestive of cerebellar involvement. The cerebrospinal fluid was under excessive pressure but was clear and there was nothing abnormal detected therein.

The diagnosis of tumor of the left cerebral cortex involving the lower part of the motor cortex was made and operation advised.

Operation was carried out—an osteoplastic flap being raised on the left side. This revealed in the left temporal region a subcortical swelling which was discovered to be a simple hydatid cyst, about 3 inches in diameter. This was removed intact and the wound closed without drainage.

Convalescence was uneventful and 3 weeks after operation the patient reported that the headaches had gone completely while the facial paresis and speech difficulty were clearing up.

Four days after operation a Casoni interdermal test was carried out, the response being a small wheal with a large area of erythema, but with no delayed reaction. It would probably have been recorded as an equivocal reaction had not the history been known.

Fig. 4. Case 1. Patient 8 months after operation. Hair clipped to show scar.

This case is of interest in that it is probably a primary cyst of the brain in an adult—a rare condition although two other probable cases have been recorded in Australia, while a number of isolated cases have been reported in other countries. The percentage of primary hydatid cysts of the brain in the adult is from 0.5 per cent to 0.7 per cent—a low figure because of the rarity of infestation in the adult and because the embryo has to make its way through the capillary beds of the liver and lung, after which only a small percentage can enter the carotid arteries, owing to the manner in which they arise from the relatively much larger aorta.

Although I have not sufficient statistics for accurate deductions, it is suggested that the left carotid would receive a larger percentage and so cysts of this class should be more frequent in the left cerebral hemisphere. It is probable that in this case infestation with the parasite occurred relatively recently, certainly not more than—judging from the size of the cyst—5 or 6 years previously, not a very common occurrence in adults who are not nearly so susceptible to helminthic infestation as children. It is also—arguing by analogy with other cases of extrahepatic cysts—probable that this patient has a somewhat smaller hydatid cyst in the liver, which is at present undetectable, but which may manifest itself in later life. Certainly she should be kept under observation for a prolonged period and any symptoms referable to the hepatic area viewed with the greatest suspicion.

Fig. 5. Hydatid cyst of the left lateral lobe of the cerebellum from a child aged 3. By courtesy of Dr. E. Britten-Jones. The cyst which has fallen out of its cavity has been injected with gelatine, hence its dark color.

Treatment of primary cysts. These cysts, like all non-infiltrating intracranial tumors, cause death by gradually increasing pressure effects, so that surgical interference is the only treatment. Provided localization is accurate, and with modern methods this should always be the case, the operative procedure is relatively simple. It should follow the methods laid down so ably by Cushing and his school of neurosurgery, and the operative mortality should be extremely low. It entails the turning down, under local anæsthesia, of a suitably placed osteoplastic flap, the tapping, sterilization and evacuation of the cyst and its laminated membrane, followed by closure without drainage. Just as in the case of other univesicular fertile cysts the real risk is infection of the area of operation by scolices. These may, under favorable conditions, form new cysts, and lead after a few years to local recurrence in the form of a multivesicular cyst. This has been recorded on several occasions and must be carefully guarded against. If the cyst is comparatively superficial and if there is no evidence of its actual contact with the walls of the lateral ventricle—partial evacuation through a needle and the injection of 5 to 10 cubic centimeters of commercial formalin, which is allowed to act for 2 or 3 minutes, is the procedure to be adopted. This effectively sterilizes all the scolices in a cyst up to at least 12 centimeters in diameter, which is probably as large as they are met with in this situation, and precludes the danger of sowing fertile scolices in the area of operation. Of course, careful packing off with wet pledgets of "lintene" or similar material is also advisable as an additional safeguard. If the cyst, as in the case recorded above, has actually bared the thin ventricular wall, a protoplasmic fixative like formalin may be inadvisable, but every effort should be made by means of suction, etc., to clear out all the hydatid elements and then to sterilize the greater part of the cavity with pledgets moistened with Zenker's fluid. With care and a due appreciation of the danger of sowing scolices, the risk should thereby be reduced to a minimum.

If the cyst lies deeply it will be necessary to incise the cortical tissue through a silent area, usually with the electric knife. In order that the cavity may be easily found, complete evacuation before incision is inadvisable and when the cyst is opened the pump must be ready for full action. The crumpled, brittle, laminated membrane must be removed intact by careful coaxing through this incision, after which the above mentioned toilet is carried out. After this is complete the cavity should be filled with a properly buffered Ringer's solution and the wound closed without drainage. After-treatment resembles that after removal of any cerebral tumor, and should be completely uneventful.

In a previous work on the subject of hydatid disease in 1928, I, judging from the reported cases, emphasized the gloomy prognosis of these cases, partly because then the mortality in all cerebral operations in children was unduly high and partly because of the frequency of recurrence, owing to contamination of the wound with scolices. Thanks to the work of neurosurgeons, particularly in America, who have standardized the surgical attack on intracranial tumors with a resultant remarkable fall in mortality, and to the recognition by all observers of hydatid disease of the risk of the spread of scolices in the opera-

tion field, it would seem that nowadays prognosis should be excellent and this, I am sure, will be reflected in results in the future.

SECONDARY CYSTS

Secondary cysts are invariably metastatic, being derived from scolices brought to the brain by the blood stream. We are almost entirely indebted to Dévé, of Rouen, for his original experimental work which first placed the pathology of metastatic hydatid disease on a correct basis.

They are always secondary to intracardiac rupture of a primary hydatid cyst of the left side of the heart and are the counterpart of metastatic pulmonary cysts secondary to rupture into the right cardiac chambers.

Following rupture of a primary cyst into one of the left cardiac chambers, the scolices and brood capsules are carried into the aorta and, owing to the comparatively large lumen of these arteries, from 60 to 70 per cent of them make their way via the carotid arteries to the brain—the remainder being distributed to more distant organs. It follows, therefore, that in these cases the brain cysts are usually multiple—sometimes very numerous, although the average number is four—are of approximately the same size, are distributed bilaterally and indiscriminately throughout the cerebral or cerebellar substance, and are nearly always associated with cysts of a similar nature and stage of development in organs such as the spleen or kidney.

The fate of the original primary cardiac cyst varies; it may be completely evacuated, undergo fibrosis and obliteration, but more often after closure of the rent, some residual scolices or brood capsules give rise to reactive daughter cyst formation inside the original cavity, so that by the time the metastatic cysts are of an appreciable size, a matter of a year or two, the original single cardiac cyst is represented by one containing numerous daughter cysts (Fig. 6).

Many such cases have been recorded in the literature but in most of them, owing to incomplete observations at autopsy, or to nonrecognition of the correct pathological story, their true significance has been missed and the real connection between the cardiac and the cerebral cysts has not been appreciated. It follows that the discovery at autopsy of multiple cerebral hydatid cysts should always lead to a close examination of the heart for the primary cyst, which will be found either in involution or containing daughter cysts. Conversely, a cardiac cyst with daughter cysts should lead to a brain examination.

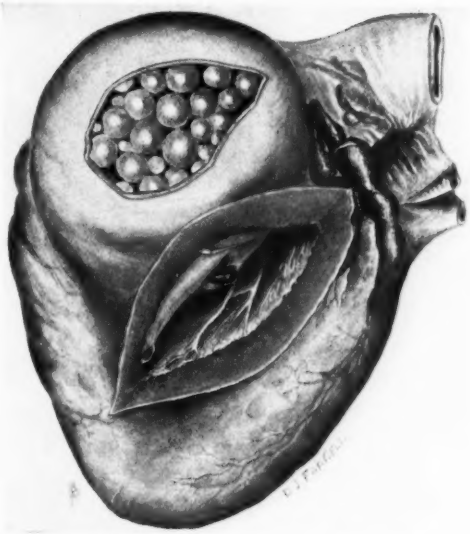

Fig. 6. Multivesicular primary cyst of the cardiac muscle from a patient aged 24. Associated with multiple metastatic cerebral cysts which caused death. From the Pathological Museum, University of Sydney.

Clinical aspects. Owing to the fact that the original cardiac cyst must have grown to a size large enough to lead to rupture and to the necessity for a certain time—1 to 5 years—to elapse to allow the cerebral cyst to grow to a size large enough to produce symptoms, this type is rare in children. The youngest patient of which I have any record is a case recorded by Verco and Poulton; a boy aged 14. The average age in an Australian series of 7 cases was 22 years. Practically all cases of hydatid disease of the brain in adults are of this type and so offer a remarkable contrast to the disease in this site in children.

The clinical picture may be divided into three phases and, if an accurate chronological story is obtainable, these should always be recognizable.

Fig. 7. Case 3. Multiple metastatic hydatid cysts, secondary to a cardiac hydatid. These cysts were all of the same size, that of a pigeon's egg, and were all simple univesicular cysts. The liver also contained a small cyst of about the same size in the upper part of the right lobe. The lungs were clear but a small hydatid 2 inches in diameter, containing numerous small daughter cysts was found in the wall of the left ventricle of the heart. This was in all respects similar to that shown in Figure 6.

1. The initial intracardiac rupture of the simple univesicular primary cyst is usually associated with sudden collapse, urgent dyspnœa, cardiovascular disturbances, or varying symptoms of an anaphylactic nature. This is due to the sudden introduction into the blood stream of a sensitized patient of the specific antigen, and although in rare cases death may be produced, in the case of a small cyst it is conceivable that little effect would be noticeable. In few, if any, of the recorded cases has this point been emphasized, mainly because it was not searched for, but often probably because it had been forgotten by the patient. Careful investigation would no doubt reveal some illness which would suggest an anaphylactic attack. The patient recovers completely and rapidly, on examination appears normal, then passes into the second phase.

2. A phase of latency extending over a period of 1 to 5 years during which the metastatic cysts grow while the original cardiac cyst undergoes obliteration by fibrosis or reactive daughter cyst formation.

3. A phase of development of increased intracranial pressure from the growth of the secondary cysts. Owing to the fact that these cysts are multiple and distributed in a widespread fashion, it follows that the cerebral signs and symptoms may be protean, rather like that due to metastatic neoplastic disease, so that accurate localization may be difficult or impossible. As the skull of adults is dense and resistant, bony changes are not common—indeed there is nothing in these cases to distinguish them from any other causes of increased intracranial pressure.

Death in this type is brought about, either from the results of increased intracranial pressure, the intensity and rapidity of development of which is dependent on the number of metastatic cysts present, or follows a second intracardiac rupture of the now multivesicular primary cyst. The latter event produces severe anaphylactic shock and owing to the comparatively large size of the daughter cysts, a rapidly fatal hydatid embolism of the main cerebral arteries. The following is a typical history of secondary cerebral echinococcis.

Case 4. K. B., female, aged 18 years, admitted to hospital with signs of increased intracranial tension.

About a year before admission the patient had had an attack of what was, because of the occurrence of urticaria, etc., thought to be "ptomaine poisoning." Some hours after a meal of saveloys she became very ill with vomiting, colic-like abdominal pains, and collapse. She remained in a more or less unconscious condition for 2 days. When she recovered consciousness she felt well but could not walk in comfort for some days because of painful contractions in the muscles of her legs. After a few weeks she was apparently normal.

History on admission. Three months before admission she had noticed intermittent occipital headache and interference with visual acuity. Two months later she noticed weakness of the left upper limb and a week later had attacks of vomiting unrelated to the taking of food. During the last few days the headaches had become much worse and more or less continuous and she had developed photophobia. All her other functions appeared normal.

Physical examination. The patient's face was expressionless and she was mentally dull. She showed ptosis of the right eye but no strabismus, no diplopia, and no nystagmus, while the pupils reacted to light and accommodation. Examination of the func

showed bilateral papillœdema—more marked in the right eye. Her fields of vision were not charted. There was a left sided facial paresis of the supranuclear type, but all the other cranial nerves seemed normal. There was a distinct weakness of the left arm—the dynamometer readings being right 30, left 10. The superficial abdominal reflexes were present but were less active on the right side. The knee, ankle, and arm joints were all equal and fairly active. The plantar reflexes were equivocal but were taken as flexor. The gait was tottering with uncertain equilibrium, but there was no tendency to fall in any one direction.

The apex beat of the heart was in the fifth space, 3.5 inches from the midline—there was no increase of left cardiac dullness. A midsystolic bruit was heard just inside the apex beat and up to the first interstal space; other cardiac sounds were clear. Lungs and other organs appeared to be normal.

Operation. A right sided cerebral exploration was carried out; great increase of intracranial pressure was found, but as no new-growth or cyst was discovered, a simple decompression was carried out. After operation a large cerebral hernia developed and the patient died in coma, some 4 weeks later.

Autopsy. Multiple hydatid cysts of the brain were found: four in left frontal region, one in each parietal lobe and one in left cerebellar hemisphere (Fig. 7).

This case is classical and instructive. There can be little doubt that the attack 12 months previously was due to hydatid anaphylaxis and coincided with the initial intracardiac rupture of the primary cyst and that the diagnosis of ptomaine poisoning was erroneous. The period of a year's latency followed by the development of the signs of increased intracranial tension, coincides with the size of the metastatic cysts of the brain and liver and with the reactive daughter cysts in the original cardiac cyst. The protean and rather puzzling nervous manifestations were due to the multiplicity of the cysts and made accurate localization impossible.

In this case—although in retrospect the diagnosis is easy—a correct diagnosis was not made until autopsy. There is little doubt that in these cases, owing to the absorption of comparatively large amounts of hydatid antigen, the Casoni intradermal test and the hydatid serological reactions should give almost universally positive findings, but until this is carried out as a routine or until we discover the criteria by which we can detect a quiescent cardiac hydatid, the antemortem diagnosis of these cases must always remain a matter of chance.

Owing to the multiplicity of the cerebral cysts and to the presence of a cardiac cyst which is in imminent danger of a secondary rupture, no treatment is of any value in these cases and operation is contra-indicated.

SUMMARY

1. There are two distinct varieties of hydatid of the brain—primary and secondary.

2. Primary cysts occur almost exclusively in young children, are simple, and give rise to similar clinical syndromes to any other benign, non-infiltrating tumors, and are amenable to surgical operation.

3. Secondary cysts are metastatic, occur almost exclusively in adults or adolescents, are secondary to an intracardiac rupture of a fertile primary cyst into the left side of the heart.

4. They produce protean nervous manifestations owing to their multiplicity, and invariably produce fatal results, not being amenable to surgery.

5. The diagnosis of either type may be suspected in "hydatid" countries, but even there may depend on positive intradermal or serological reactions.

I have to acknowledge with gratitude the courtesy of Drs. Temple Smith and R. B. Wade of Sydney, Dr. Britten-Jones of Adelaide, and Mr. W. A. Hailes of Melbourne, who have put their records at my disposal and given me access to their cases.

REFERENCES

1. Chiappori, R. Trabajos 2nd Nacional Congreso de Medicina. p. 485. Buenos Aires, 1922.
2. Dew, H. R. Hydatid Disease. p. 366. Sydney: Australian Medical Publishing Co., 1928.
3. Morquio, L. Rev. med. d. Uruguay, 1901, No. 2, 210.
4. Pflaumer, J. Argentina Med., 1905, September, 408.
5. Verco, J., and Poulton, A. Australian Med. Gaz., 1906, June 20, 265.

THE SURGICAL TREATMENT OF EXOPHTHALMIC GOITER
LATE END-RESULTS

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ALTHOUGH the basic cause of hyperthyroidism is unknown, the most efficient treatment is the operation of subtotal thyroidectomy. By this procedure, the surgeon breaks a vicious circle which involves the thyroid gland, other glands of internal secretion, and the sympathetic nervous system.

During recent years, many papers on various aspects of exophthalmic goiter have been published, the great majority from American clinics. The outstanding contributions have been the isolation of thyroxin by Kendall and the rationalization of iodine therapy by Plummer. Many of the articles have dealt with such topics as the technique of thyroidectomy, operative mortality, the multiple stage operation, the management of the "poor-risk" and the "thyro-cardiac," the basal metabolic rate, and the estimation of end-results. These publications, representing the experiences of authorities in the most prominent clinics, have served to crystallize our present knowledge of the various aspects of the disease.

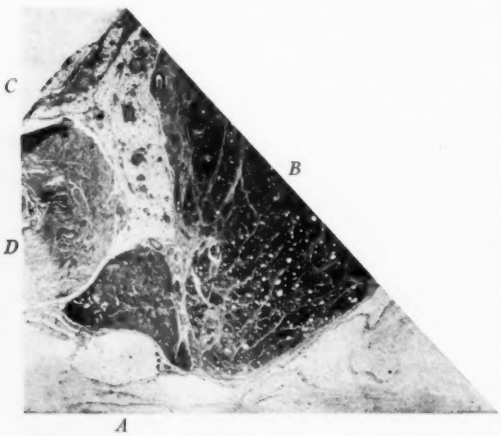

Fig. 1. Approximate line of division when posterior part of lobe is left so as to safeguard the parathyroids and recurrent laryngeal nerve. A, Parathyroid; B, thyroid; C, position of trachea; D, œsophagus. Recurrent nerve lies between thyroid and trachea (magnification ×8). From *Ann. Surg.*, 1916, lxiii, 71.

Since the earlier years of our experience, it has been our belief that the enlargement of the thyroid gland is merely an incident in a general disturbance and that the operation of subtotal thyroidectomy is only a makeshift for want of the elimination of the actual cause of the disease. We argued that, if the same factors which initiated the disease remained active after operation, many recurrences would be noted if the patients were observed for a long period. We, therefore, decided to follow every case indefinitely. This paper, then, constitutes an analysis of 225 cases of exophthalmic goiter treated on the Second Surgical Division of the old New York Hospital, which were carefully followed by repeated examinations during the period of years between 1915 and 1932. It must be emphasized that these were all ward patients, and after discharge from the hospital, it was usually impossible to eliminate or correct the factors which seemed to be contributory in initiating the disease. This feature is less important in private patients since their lives may be more effectively regulated. Our private cases, which constitute a larger series, were, of necessity, not included in the follow-up clinic. The results, both immediate and late, were better than those noted in this series of ward cases, but it has not been feasible to reduce these results to figures.

In the series of 225 patients, there were 179 females and 46 males, a ratio of approximately 4 to 1. Between the years 1915 and 1929, 20 males were admitted for treatment. From 1929 to 1932, there were 26 men. These figures suggest that the incidence of exophthalmic goiter in the male was markedly increased following the great stress and strain subsequent to the depression of 1929.

An analysis of the age grouping reveals the interesting fact that the vast majority of patients fall into the third and fourth decades,

Fig. 2.

Fig. 3.

Fig. 4.

g. 2. Retraction of sternohyoid and division of sterno-
th oid.

g. 3. Insertion of special curved clamp between isth-
m and trachea. When the clamp is opened the isthmus
is parated from the trachea without hæmorrhage, two special clamps are then placed on the isthmus which is divided between them. From *Surg., Gynec. & Obst.*, 1930, l, 1001.

Fig. 4. Isthmus divided between clamps and dissected from trachea. From *Surg., Gynec. & Obst.*, 1930, l, 1001.

in he period of greatest activity. There were 3 patients in the second decade, 77 in the th rd, 73 in the fourth, 31 in the fifth, and 13 in the sixth.

The occupations of the patients elicited some interesting facts. One hundred and two gave their occupations as housewives. Careful questioning indicated in almost every instance either excessive work, financial distress, too many pregnancies or marital difficulties; 77 were listed as factory workers. This group suggests again the possibility of stress and strain as activating factors. The remainder were scattered among the classifications of

Fig. 5. Superior vessels have been divided and lobe freed laterally. Clamps are placed along posterior part of the lobe and lobe removed anterior to them. From *Surg., Gynec. & Obst.*, 1930, l, 1001.

Fig. 6. Resection has been completed leaving a small part of each lateral lobe. From *Surg., Gynec. & Obst.*, 1930, l, 1001.

Fig. 7. Special double-tooth thumb forceps approximate skin edges to facilitate application of Michel clips. From *Surg., Gynec. & Obst.*, 1930, l, 1001.

laborers, teachers, school girls, and stenographers.

Many of the patients suggested events in their lives precipitating their illnesses. Thus, 21 indicated that constant worry was a factor, 10 had family difficulties, in 18 cases there was a sudden death in the family, 12 followed severe infectious diseases, 8 were precipitated by childbirth, and 7 gave financial worries as a possible cause. In 2 cases, the train of events was quite dramatic. Both patients were young women who were badly frightened by a hold-up. Within 2 weeks, each presented the classical signs of a severely toxic exophthalmic goiter. One of these patients had been seen 3 weeks before in the gynecological clinic and, at that time, there was no indication of the presence of hyperthyroidism.

The majority of the patients sought treatment within 12 months of the onset of the disease. Thus, 79 had symptoms from 2 weeks to 6 months; 45 from 6 to 12 months; and 28 from 12 to 18 months. There were 31 patients who apparently had the disease for more than 4 years.

A survey of the histories of these patients indicated that the majority presented symptoms usually associated with hyperthyroidism; namely, tachycardia, tremor, goiter, palpitation, asthenia, nervousness, emotional instability, dyspnœa on exertion, excessive sweating, and attacks of diarrhœa. Approximately 50 per cent showed exophthalmos. Excessive appetite was a common complaint. Menstrual irregularities were frequent. Loss of weight was common: 11 patients lost from 1 to 10 pounds; 51 from 10 to 20 pounds; 9 from 20 to 30 pounds; and 30 lost more than 30 pounds. Eleven patients stated that there had been no weight loss. The size of the goiter and the degree of toxicity were not commensurate. Many patients with barely recognizable enlargement of the thyroid presented marked toxicity.

The findings on physical examination were fairly constant. Most of the patients presented psychomotor activity, mental apprehension, tremor, sweating, muscular weakness, enlarged thyroid gland of varying degree, rapid pulse, elevated blood pressure, skin of fine texture, tapering fingers. About 50 per cent presented exophthalmos of varying degrees with the associated confirmatory eye signs. In 108 cases, there was a systolic murmur at the apex. Diastolic murmurs were detected in 8 instances. Ten patients had marked auricular fibrillation. In 88 patients no detectable cardiac abnormality was presented. Cardiac enlargement was noted in 20 cases. Every patient, after admission to the hospital, was subjected to electrocardiographic examination. That these abnormal heart findings, in most instances, are of but transient significance, is evidenced by the fact that careful follow-up studies indicated their eventual disappearance. Six of the 10 patients admitted with auricular fibrillation subsequently regained a normal heart rhythm.

Before the use of iodine (Lugol's solution) in October, 1924, the ante-operative preparation of these patients was relatively ineffective and the operative mortality was high. The employment of Lugol's solution in the pre-operative preparation immediately improved the results. The symptoms of exophthalmic goiter, as a rule, are quickly ameliorated following the administration of Lugol's solution. Elderly patients, however, do not respond as quickly as younger ones. Patients who have had iodine before hospitalization are particularly resistant to its pre-operative administration. Some patients were definitely "iodine-fast." Most of the cases in the latter group were discharged from the hospital to rest for a period of 2 or 3 months without iodine therapy. Upon readmission, their

response to Lugol's solution was usually satisfactory. Another group showed marked improvement following the removal of foci of infection, as diseased tonsils and carious teeth, and subsequently showed a more rapid response to iodine. The usual effect following the administration of Lugol's solution (minims 10 to 15 three times a day), is a marked fall in the basal metabolic rate within eight to ten days, gain in weight, drop in the pulse rate, and general improvement. Some patients need a longer period to exhibit this improvement. Each patient is an individual problem.

The first basal metabolism estimation was done in March, 1921. Since then, the test has been in constant use and has proved a most valuable aid in determining the degree of toxicity and the extent of improvement. Within recent years, however, we have relied less upon it as an indication for instituting surgical therapy. Rather are we stressing more the clinical improvement as shown by a drop in pulse rate, general well-being of the patient, and, particularly, by a definite gain in weight. We feel, in general, that no operative procedure should be attempted in the presence of loss of weight. This must mean that catabolism overbalances anabolism and that thyroid activity is too great to permit of safe surgery. The records indicate that, when thyroidectomy was performed during a weight loss, severe postoperative reactions or a mortality resulted.

TECHNIQUE OF THYROIDECTOMY

The operation of thyroidectomy is fairly well standardized. There are minor differences in the technique of all surgeons, but they are relatively unimportant. In 1930,[1] we reported a method which advised division only of the sternothyroid muscles near their insertion and the division of the isthmus. Division of the isthmus was practiced by us as early as 1915. In most instances, splitting of the isthmus is easily done, but, occasionally, when it is markedly hypertrophied, it is unwise to attempt this method. Although the general details of the technical side are important, the thyroid surgeon must evolve for himself an operative procedure which minimizes bleeding, permits of adequate exposure, reduces trauma and can be executed quickly and safely.

Prior to the employment of Lugol's solution, a graded operation consisting of polar ligation followed by unilateral or bilateral lobectomy was commonly employed. We believe that little is accomplished by a polar ligation. Its effect is uncertain. Since 1926, polar ligation has been done in only 2 cases. However, it is still occasionally necessary to perform thyroidectomy in two stages: i.e., one lobe and isthmus at the first operation and the second lobe at a later date. The decision as to which patient will need a multiple stage operation comes with experience and cannot be obtained by following any set rules. One is influenced by the intensity of the disease, the course while being prepared for operation, and the reaction on the operating table during the initial procedure.

ANALYSIS OF CASES

Polar ligation. In 17 cases, unilateral or bilateral superior pole ligation was performed and no subsequent surgery was carried out. Five patients died after operation, 4 with symptoms of a thyroid storm, and 1 of heart failure. These deaths occurred prior to 1926. Eight of these patients refused to have anything further done. They were followed from 6 months to 4 years. Little change in their conditions was noted. In 1 patient, further surgery was inadvisable because of the development of mental disease requiring state hospital care. One patient, followed for 3 years, showed such marked improvement that further surgery was not recommended. Still another was followed for 4 years; at the end of that time, she presented none of the signs of hyperthyroidism. One patient died of luetic aortitis 5 years later.

Ligation followed by resection in one or two stages—26 cases. Four died after operation; in 2, both prior to 1923, thyrotoxicosis was responsible for the fatality; 1 developed a wound infection, followed later by hæmorrhage. Death occurred on the sixteenth day and autopsy disclosed a large thymus, pericarditis, and pleural effusion. The fourth patient died suddenly 48 hours after operation. Post-

[1] Surg., Gynec. & Obst., 1930, l, 1001—Figs. 1–7.

mortem examination disclosed a hæmorrhage into the superior mediastinum.

Careful follow-up data are available in the 22 remaining cases. Thirteen patients were followed for from 1 to 10 years, the average period being 7 years. During their entire follow-up period, these patients remained free from any evidences of recurrent hyperthyroidism and were rated as 100 per cent results. We wish to emphasize that all of the cases reported in this paper were carefully examined, following a complete history-taking every 4 to 6 months after discharge from the hospital. These personal examinations were supplemented by basal metabolism determinations in many instances. We believe that follow-up records based on letters are inaccurate and that a personal approach alone is reliable. We regard this record of our experiences as significant, especially from the standpoint of the recurrence rate. Frequently, a recurrence was noted before the patient offered any complaints.

The 9 remaining patients developed recurrences; that is, enlargement of the thyroid with toxic symptoms. They are herewith summarized:

CASE 1. A small recurrence was noted on the right side after 2 years of good health.

CASE 2. A small recurrence was noted on the left side after 2 years of good health.

CASE 3. After 2 years of excellent health, patient developed a large recurrence following a difficult childbirth. A second resection was done. Two years later she was rated 100 per cent.

CASE 4. After 8 years of freedom from symptoms, this patient was badly frightened in an automobile accident. A few weeks later she exhibited the signs of a mild hyperthyroidism with small nodules in each lobe. After a course of X-ray therapy, all symptoms disappeared and the patient has been well for 2 years.

CASE 5. A large recurrence was noted after 1 year. A second resection resulted in an operative mortality.

CASE 6. A recurrence was noted within 6 months. Following the second resection, the patient has remained well 4 years.

CASE 7. This patient remained well for 4 years before she developed a recurrence. A second operation resulted in freedom from symptoms for 2 years. Following a difficult family situation, a small recurrence was noted on the right side.

CASE 8. After 2 years of excellent health, a small recurrence developed on the right side. Tonsillectomy and radiotherapy brought relief. This man has been perfectly well for 2 years.

CASE 9. Except for cardiac symptoms due to chronic cardiac valvular disease, this patient was well for 3 years. After severe financial reverses in 1929, a large recurrence was noted. This was again resected in two stages. The patient died suddenly 1 year later of heart failure.

Resection in two stages without previous ligation. There were 3 cases. They are classified as 100 per cent cures, after 3, 7, and 9 years respectively. (One patient died after operation of thyrotoxicosis after resection of one lobe, a two stage procedure having been planned.)

Primary resections in one stage. This group constitutes the bulk of the series, 178 cases. There were 7 operative deaths, most of them occurring before 1928. In 5 cases, the cause of death was postoperative thyrotoxicosis. One patient died suddenly of heart failure on the fourth postoperative day. In the seventh case tetany developed and did not respond to treatment. The mortality rate for this group was 3.9 per cent. However, the records indicate that most of the deaths occurred in the earlier days of our experience. More recently, there has been marked improvement. In the last 107 cases, there has been 1 death, or a rate of less than 1 per cent.

Careful follow-up data were obtained in the remaining 171 cases. One hundred and fifty followed for from 6 months to 9 years were classified as 100 per cent. In other words, these patients were perfectly well and presented none of the symptoms of hyperthyroidism. Of these, 35 were followed 6 months, 41 for 1 year, 37 for 2 years, 18 for 3 years, 4 for 4 years, 9 for 5 years, 4 for 6 years, 3 for 7 years, 1 for 8 years, and 3 for 9 years. Five patients were classified as 90 per cent. Three presented a persistent exophthalmos, and 2 retained their tremor.

In the 16 remaining cases recurrences developed and it is upon these that our interest is centered. They are herewith summarized:

CASE 1. Symptoms returned within 6 months. One year later (1918) a second resection was done. The patient died after operation. This should be classed as a persistent hyperthyroidism, because it seemed evident that the resection was insufficient.

CASE 2. A small recurrence was noted after 1 year. The patient was then lost from follow-up.

CASE 3. A recurrence was detected after 2 years. A second resection was done. Later, a recurrent nodule was felt in the left upper pole. This disappeared after a course of radiotherapy. The patient has remained well for six years.

CASE 4. Recurrence after 1 year. Second resection was then done. Patient has remained perfectly well for 7 years.

CASE 5. This patient's course is quite significant. She remained well for 9 years, when, after financial reverses, she developed a large recurrence rather suddenly. She refused further surgery.

CASE 6. Two months after operation, a large nodule was detected. This should be classed as persistent hyperthyroidism. A second resection was then done. One year later a small recurrence was noted. This responded quickly to X-ray. She has been well for 4 years.

CASE 7. Persistent symptoms after 3 months. The resection had not been radical enough. A second resection was done at another hospital. Four years later she returned presenting a large recurrence. She refused further surgery. This patient was constantly combating adverse environmental conditions which could not be corrected.

CASE 8. This patient was classified as 100 per cent for 3 years. Following a harrowing experience in an automobile accident, she developed a large recurrence. A second resection was done. She has remained well for 2 years.

CASE 9. After 5 years of excellent health, patient developed a small recurrence with mild symptoms. A change of environment brought quick relief.

CASE 10. Symptoms returned in 6 months, due probably, to insufficient resection. Because further surgery was refused, X-ray therapy was instituted. Although benefited, she still presents evidences of hyperthyroidism.

Radiotherapy has given us best results with small recurrent nodules. They frequently disappear or are replaced by scar tissue. When the recurrences are large, the X-ray seems to have little influence.

CASE 11. A recurrence was noted in 6 months. Two years later a second resection was done. The patient has remained well for 2 years.

CASE 12. A small nodule was detected after 6 months. The symptoms were mild. This case was subsequently lost.

CASE 13. A recurrent nodule was detected after 8 months. Basal metabolic rate was 33 per cent. Radiotherapy was instituted. The patient has been well for 2 years.

CASE 14. Within 1 year, a large mass was palpable. Judging from the operative description, only a partial thyroidectomy was performed. Further follow-up data are not available.

CASE 15. This should be classed as a persistent case due to inadequate surgery. Signs of hyperthyroidism returned within 9 months.

CASE 16. This is another case of persistent hyperthyroidism from insufficient surgery. Symptoms returned after 3 months. A second resection was followed by good health which has continued for 1½ years.

There seems little room for doubt that the occasional thyroid surgeon will have a high recurrence rate because of inadequate surgery. Timidity because of fear of injury to the recurrent nerves and the parathyroid bodies and operative indecision because he has not yet developed a standard procedure, are probably the reasons for this. At least 7 cases in the above 16 recurrences were operated upon by members of the staff who only occasionally performed thyroidectomies. The occasional goiter surgeon must expect many recurrences. It takes considerable experience to operate efficiently and adequately in this disease. The recurrence rate in this group of 171 primary resections was 9.3 per cent.

POSTOPERATIVE COMPLICATIONS

Not infrequently during the course of a thyroidectomy, the anæsthetist will inform the surgeon that the pulse rate is rising or that he is not satisfied with the patient's condition, and request him to terminate the operation as quickly as possible. Under such circumstances, we have made it a practice to leave the wound open, packing it with vaseline gauze or gauze soaked in Dakin's solution. In 2 or 3 days, a delayed primary closure may be done safely. The wound was left open sixteen times in this series. Four of these patients died after operation. In 2 cases a mild wound infection resulted. In the entire series, there were five wound infections, but none of them was of a serious nature.

Aside from the patients who died, there were only 5 instances of severe postoperative reaction. The liberal use of intravenous glucose, morphine, and iodine mainly by vein, resulted in recovery. One patient developed a hemiplegia after a cerebral embolus. There was only one instance of recurrent nerve injury. Careful laryngeal examinations were made, as a rule, before and after operation. Two patients developed postoperative tetany. One was transient and responded quickly to parathormone and calcium therapy. The

other succumbed, mainly because of a thyrotoxicosis.

The low incidence of pulmonary complications after thyroidectomy is noteworthy. In this group, there were 2 cases of postoperative pneumonia and 2 of massive atelectasis. All 4 patients survived. There was 1 patient who developed pericarditis. This was one of many complications which led to her death.

Three patients developed a wound hæmorrhage. In one case, it occurred on the sixteenth postoperative day and was one of many complications. The patient died of other causes. In the second case death came suddenly on the second day with few evidences to suggest such a complication. At postmortem, it was found that the neck wound was remarkably free of blood, but that blood had gravitated into the superior mediastinum. The third patient, about 6 hours after operation, suddenly developed symptoms to suggest recurrent nerve injury. Laryngeal examination indicated bilateral nerve paralysis. Inspection of the neck showed a marked bulging in the operative area. The wound was opened widely and the blood clots evacuated. A tracheotomy was then done. This patient recovered quickly and completely regained the function of his vocal cords.

When a wound hæmorrhage is suspected and it is severe enough to cause obstructive symptoms, the condition should be treated as an emergency. Wide opening of the wound, evacuation of the blood clots, and the insertion of gauze packing usually suffice.

CONCLUSIONS

1. Enlargement of the thyroid gland is only an incident in the disease of exophthalmic goiter.

2. The operation of subtotal thyroidectomy is but a makeshift for want of the elimination of the actual cause of the disease.

3. If the same factors which initiated the disease remain operative after operation, many recurrences will be observed if the patients are followed for a long period.

4. In 194 cases, carefully followed over a period of from 6 months to 10 years, there were 25 recurrences, or a percentage of 7.7.

GASTRIC RESECTION FOR PEPTIC ULCER: TECHNIQUE[1]

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WIDE resection of the stomach as a routine procedure for simple benign but resistant ulcer of either duodenum or stomach has found a prominent and, I believe, a permanent place in the continental European literature of gastric surgery. The American literature reflects a far more conservative attitude yet I believe there is an ever widening circle of accepted indications for more radical procedure. This development has been rather irregular along several lines. The technique has varied and the objective has not always been the same. The purpose of this paper is to present the writer's idea of the objective to be attained in wide resection and to give a short description of the more important steps in the technique.

First, it is important to emphasize that neither neutralization nor reduction or elimination of acidity is an objective of resection. These can be attained by simpler means. Neutralization and reduction of acidity are incidentally attained and have the same auxiliary value as when obtained in the simpler operations or by adequate non-surgical treatment. The objective of resection is quite different. For all practical clinical purposes peptic ulcer may be said to be almost limited to a very restricted portion of the stomach and duodenum. This is the lesser curvature and distal half or more of the stomach and first portion of the duodenum. This is so true that this may be regarded as a distinct area, the ulcer-bearing segment. The objective of gastric resection for a benign ulcer is the removal of this segment. When adequately executed, recurrence must be extremely infrequent. Conversely, failure, with recurrence of ulcer is probably most frequently due to a failure to accomplish a sufficiently wide resection, though technical errors, such as spur formation, badly arranged gastrojejunal anastomosis, etc., probably play a part. That we in America have a relatively larger number of failures than is admitted by European surgeons is quite probable, for a larger number of our cases are among the earlier attempts of surgeons not entirely familiar with the technique or the objective sought. What amounts to the removal of the pyloric ring with more or less of the antrum is not to be confused with the operation here described. It is unfortunate that the failures of such limited operations should be included in reports of failures of wide resection. The size of the ulcer, its multiplicity, the area involved, are not to be regarded as factors in determining the extent of the resection. If resection is indicated at all it should be a wide resection.

Few steps in so fully developed an operation as resection of the stomach can be expected to be original. However, several operations have been developed differing quite radically from each other in principle and the various steps of these operations have varied in the hands of different surgeons. It is the writer's purpose to describe in detail the more important steps of the operation which he prefers. This is a wide resection of the stomach, including especially, the lesser curvature, the *magenstrasse*, with the end-to-side gastrojejunal anastomosis which had its origin in the second operation of Billroth, and has been so widely modified. The end-to-side operation of gastroduodenostomy more recently developed by Haberer is technically simpler and physiologically logical, but is objectionable in that it necessitates very conservative resection of the stomach. The illustrations in Haberer's original paper show an antrectomy, which I believe is not satisfactory. It may be considered a satisfactory substitute for the various ulcer excisions and pyloroplasties, but not for resection.

PREPARATION OF THE PATIENT

Partial gastric resection is rarely an emergency operation. There is usually adequate time to get the patient in the best possible condition to withstand a major operation. A few conditions may militate against delay for preparation.

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Severe hæmorrhage can usually be controlled by various means, including, first and foremost, adequate blood transfusions. Occasionally hæmorrhage persists and surgical interference is indicated. In such a case a final transfusion just before operation may be of the greatest value. Operation during profound hæmorrhage without such a supporting transfusion seems to me to be inexcusable.

Severe starvation and particularly dehydration from high grade pyloric stenosis offers a serious problem. Water, salt and glucose, intravenously, subcutaneously, and rectally, and blood transfusions offer ample means of improving the patient's condition sufficiently to operate in most cases. Rarely a jejunostomy may be indicated after the water balance has been adjusted. The jejunostomy should be low enough to permit the required operative maneuvers later. It serves a useful purpose in permitting operation to be deferred until the patient's condition is entirely satisfactory. It should be utilized after the resection until normal feedings can be instituted.

Acute perforation of an ulcer constitutes an urgent indication for operation. Most surgeons prefer some simple method of repair of the perforation to more radical measures. However, many patients remain in excellent physical condition for some hours after perforation occurs. As was pointed out years ago by Moynihan, these patients are not in shock. The agonizing pain is disabling, but the blood pressure remains normal, or may rise. The peritonitis is not at first an infective process, but a reaction to a chemical irritant. Under these circumstances resection can usually be performed quite as safely as under more usual conditions. An excessive inflammatory œdema about the pylorus and duodenum may make the freeing of these parts more difficult, and constitute the only objection to proceeding with the resection. The peritoneal exudate is not a disturbing factor. It should be removed with an aspirator. After some hours, the inflammatory process becomes an infective affair, and the patient's condition becomes poorer; resection is then contra-indicated.

In the absence of such complications as these, many patients can be operated upon after such usual pre-operative measures as apply to most major cases. By means of proper dietary measures, the use of the nasal or stomach tube to insure emptying of the stomach at night, etc., the internist can substantially reduce the size of a dilated stomach and make easier the surgeon's work. Duodenal feeding may greatly reduce the inflammatory swelling about a lesser curvature or duodenal ulcer. Much can be done toward improving the general condition of a patient weakened by greatly reduced food intake, or prolonged or repeated minor hæmorrhages.

Finally, in common with all major operative cases, the patient's blood grouping should be determined, and there should be on call proper donors to be used should the need arise.

The Levine nasal tube has proved to be of great value. It is passed the evening before operation in cases of retention and allowed to remain; or just before operation where no retention exists. Siphonage with or without suction keeps the stomach empty. Toward the completion of the operation, as will be stated later, it is pushed down into the jejunum to facilitate early postoperative administration of liquids.

TECHNIQUE

The choice of incision, whether median or right or left paramedian, must ultimately be a personal one, since each has its advantages and some disadvantages. Adequate access is essential. Exploration and operative manipulation should be unhampered. The study includes the condition of the lesion and the extent of its inflammatory fixation to pancreas, liver, or other adjacent organ. A small duodenal ulcer may be overlooked in the presence of a large deforming ulcer on the lesser curvature. An old gastro-enterostomy usually adds considerable technical difficulties. A pathological gall bladder or appendix must not be overlooked. The appendix is removed routinely at the end of the operation if the condition of the patient permits; a pathological gall bladder can usually be removed, but its removal may be deferred if it seems best.

After the routine exploration is completed, the anterior surface of the stomach is grasped with two heavy forceps to be used as handles (Fig. 1). The stomach is drawn down and a finger or two of the left hand is pushed through

the almost bloodless gastrohepatic omentum to admit air to the lesser peritoneal cavity. This maneuver allows the colon to fall away from the stomach, and the transverse mesocolon from the gastrocolic omentum. This effect is increased by pushing the fingers of the left hand well into the lesser cavity, raising the stomach and pushing the colon away. There is, however, a variable extent of fusion between the mesocolon and the gastrocolic omentum. Toward the left the two structures are quite free, and fall apart quite readily. Toward the right they are usually extensively fused, though separable to some extent, an item of great importance in the technique of resection.

The stomach is now raised by the "handles" so as to present the gastrocolic omentum as a diaphanous drape showing the vascular arch formed by the coalescence of the right and left gastro-epiploic vessels, and their epiploic branches. Toward the left, large transparent bloodless areas are seen, one of which is punctured with forceps or fingers (Fig. 2), and with fingers behind them, the epiploic vessels are gathered or "bunched," grasped in groups and divided between forceps (Fig. 3). In this way the greater part of the gastrocolic omentum is divided, there being no need for meticulous care to divide individual vessels. The left gastro-epiploic vessels are divided well over toward the left side, marking the site of the intended transection of the stomach on the greater curvature (Fig. 4).

The division of the gastrocolic omentum is now carried toward the right, but here the fusion of mesocolon and gastrocolic omentum endangers the middle colic artery. Two fingers are passed behind the gastrocolic omentum (Fig. 5) and separated, and the mesocolon is thus wiped from the omentum, permitting the latter to be divided well up to the pylorus, where the right gastro-epiploic vessels are encountered and divided.

Some question has been raised as to the safety of dividing the gastrocolic omentum below the arch formed by the gastro-epiploic vessels, and sacrificing the latter, since they are the main source of blood supply to the omentum. I have carried out this maneuver in a sufficiently large number of cases without incident to feel safe in advocating it. There is a remarkably extensive network of vessels, large and small, in the omentum, which makes for safety. If any doubt is felt, in extremely fat omenta, for example, the division should be made between the arch and the stomach.

The stomach, pylorus, and duodenum are now rolled progressively upward and to the right, and the pancreas separated from them by the varied maneuvers of gauze wiping and blunt and sharp dissection. The inflammatory thickening and adhesion of the base of an ulcer on the posterior wall of the duodenum to the pancreas may obliterate the plane of cleavage and make difficult the dissection. Actual penetration of the ulcer into the pancreas may necessitate opening into the ulcer in the process of separation. The previous use of the Levine tube, and the proper placing of gauze swabs will prevent undue soiling. A considerable cavity may have been excavated in the head of the pancreas by such an ulcer. Its toilet consists in swabbing with iodine, or any other satisfactory disinfectant, and tucking a tag of omentum into it, retaining the latter with a few sutures. Such an excavation, however, must add an element of danger of infection, and drainage may be justified.

For such penetrating ulcers, the technical difficulties and added danger of infection may justify division of the stomach proximal to the pylorus, inverting the stump and leaving the ulcer behind, the ensuing steps of the gastric resection remaining the same. This procedure was advocated by Finsterer. If possible, the mucosa of the remaining segment, and especially the pyloric ring itself, should be removed. Because of its funnel shape it will be found difficult to invert the stump without removal of the mucosa unless a considerable segment is left behind, which is objectionable. I have carried out this procedure in a small number of cases, with no failure to date, but would do so only where complete resection is impracticable.

Mobilization of the first portion of the duodenum having been continued to the extent of separating its lower border from the pancreas, a Kocher dissector, or curved forceps used as a dissector, is insinuated between it and the pancreas at a point beyond the ulcer,

raising it from its bed. It is grasped with two forceps between which it is divided (Fig. 6).

The duodenal stump is inverted by a Parker-Kerr suture (Fig. 6), fine catgut reinforced with a few fine silk sutures being used. For further insurance omentum may be tacked to it or it may be sutured to the pancreas.

The pyloric stump is still held by a reflection of the peritoneum from its upper border, the right gastric artery and the remains of the gastrohepatic omentum previously punctured with the fingers. These are progressively divided, the right gastric vessels being the only structures of importance. It is necessary, however, to hug the duodenum and pylorus closely. The stomach may now be drawn well to the left, thus exposing to more ready access the left gastric artery as it extends from behind in a fold of peritoneum toward the lesser curvature of the stomach.

The left gastric artery approaches the lesser curvature of the stomach from behind, reaching the border at a variable distance from the cardia. The higher it is divided the better it permits mobilization of the stomach. It is hardly necessary, however, to divide it before it reaches the lesser curvature, except for an unusually high lying ulcer. For all practical purposes, high division on the lesser curvature (Fig. 7) and division of the stomach at this site suffices to remove practically all of the lesser curvature, which is the object to be attained.

The choice of the site of division of the stomach has varied with different surgeons. Some leave a large part of the lesser curvature, the resection really amounting to an antrectomy; Finsterer divides it in a line parallel with the long axis of the body, just to the right of the cardia, thus removing almost the entire lesser curvature. It has been suggested that after dividing the stomach the lower end of the remaining segment be cut off obliquely or even transversely; apparently with the purpose of easing the spilling of the stomach contents into the jejunum, as if it were a functionless bag. Reichel, and later, Pólya, sutured the entire end of the stomach into the side of the jejunum; Hofmeister, Wilms, and later Finsterer partly closed the end of the stomach at the lesser curvature border. I believe that Finsterer's combination of subtotal removal of the lesser curvature, spur formation by partial closure of the end of the stomach, and vertical position of the stoma in the standing position of the patient, is correct, and should form the technical basis of all gastric resections for ulcer. While the division of the stomach as here described is carried downward and to the left for the purpose of removing more of the greater curvature than Finsterer, the vertical position of the stoma is maintained by suturing the opening in the mesocolon to the stomach above the anastomosis in the usual manner. The sacrifice of more of the greater curvature is intended solely for the purpose of making it technically easier to unite greater curvature to jejunum without spur formation.

The stomach is now raised vertically and a strong, straight clamp applied to it just distal to the site of ligation of the left gastric and gastro-epiploic vessels. Thus the clamp is placed not parallel with the long axis of the body but obliquely from above downward and to the left. The division is made proximal to, and parallel with, the clamp, as follows: with the stomach and clamp turned well over toward the left, the posterior wall is exposed (Fig. 8). The incision, close to the clamp, is carried through peritoneum and muscularis down to the submucosa, readily recognized by its numerous vessels. Peritoneum and muscularis are easily pushed back with the scalpel, thus exposing an ample width of the submucosa, permitting the larger vessels to be grasped with forceps. This incision is carried from border to border and all necessary forceps applied; then the incision is carried through the remaining thickness of the stomach wall, between forceps and the clamp previously applied. The aspirator evacuates any remaining excess of liquid in the opened stomach, additional forceps are applied as needed, additional gauze swabs are placed, and the stomach is turned to the right, thus exposing its anterior wall, which is treated exactly as was the posterior wall.

It will be noted that the clamp prevents spilling and back bleeding from the segment of stomach removed, and insures division in a straight line; also that the clamp is placed on

Fig. 1.

ig. 1. With the stomach drawn d n, the bloodless gastrohepatic o ntum is punctured, admitting air to he lesser peritoneal cavity.

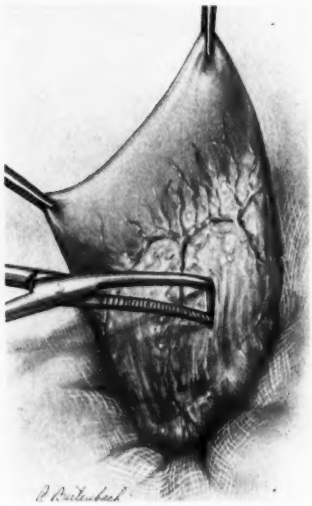

Fig. 2.

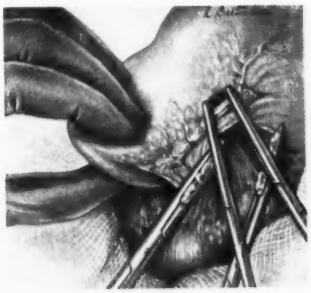

Fig. 4.

Fig. 2. With the stomach raised, a bloodless area of the gastrocolic omentum is punctured and enlarged for the admission of the fingers.

Fig. 4. The left gastro-epiploic vessels are divided well over toward the left, marking the site of division of the stomach on the greater curvature.

the part of the stomach that is removed. No clamps are used on the parts remaining.

Fine (No. 00) catgut ligatures are applied. The open end of the stump of the stomach may be reduced substantially in size during this process of ligation of its vessels, particularly by including two or more vessels in each ligature. The open end of the stomach may be sutured directly into the side of the jejunum, as by Reichel, Polya, and others.

I believe that it is preferable partly to close the end at its lesser curvature border. The formation of a spur at this situation serves to prevent the passage of stomach contents in the wrong direction (toward the duodenum). It also permits more accurate determination of the size of the stoma.

The closure is performed as follows: a fine catgut (No. 00) suture is placed at the lesser curvature, through the full thickness, tied, and the short end left long enough to be used for traction. The needle is then reinserted from within outward, emerging on either side of the median line about half an inch back of the free cut edge. The edges are now inverted by a continuous through-and-through suture of the Parker-Kerr type, until the desired size opening is left. Instead of depending upon this single inverting suture, which I have found perfectly satisfactory, an extra hæmostatic suture may be applied in the usual manner. I have used this suture only in the presence of annoying persistent oozing. A third suture, layer to layer, is quite unnecessary.

The end of the stomach is now anastomosed to the side of the jejunum by any preferred method. Of the more important details, the following should be noted.

Fig. 3. Epiploic vessels in gastrocolic omentum are "bunched" by fingers passed behind the omentum and divided in groups rather than individually.

Fig. 5. Two fingers passed behind the gastrocolic omentum toward the right push the mesocolic vessels while dividing the omentum. The right gastro-epiploic artery is ligated as it appears beneath the border of the pyloric area to the right.

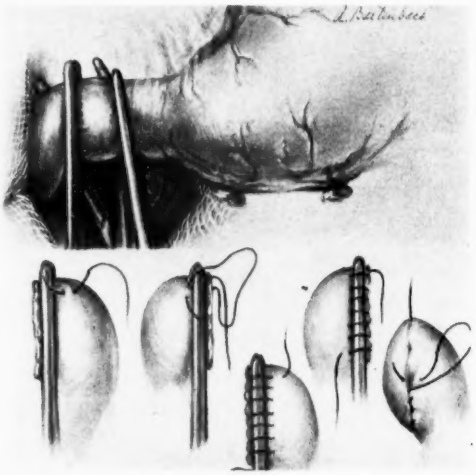

Fig. 6. A curved forceps is insinuated beneath the duodenum which is divided between forceps. The Parker-Kerr type of suture which inverts the cut edge.

The anastomosis is made close to the origin of the jejunum, the ligament of Treitz being divided if necessary to prevent angulation. Following Billroth, the earlier resections were followed by a long loop, antecolic anastomosis between stomach and jejunum, to which Braun later added an entero-entero-anastomosis to drain the jejunal loop. I believe the long loop gastrojejunal anastomosis with or without the Braun anastomosis adds a substantial danger of gastrojejunal ulcer, and should be avoided. The jejunum is carried up a short distance over the sutures originally placed in the partial closing of the cut end of the stomach, reinforcing them. This elevation and angulation of the jejunum also serves an important function in preventing regurgi-

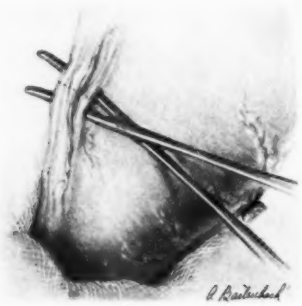

Fig. 7.

Fig. 8.

Fig. 7. The left gastric artery is divided at the level of division of the stomach after the lesser curvature is reached. In very high lying lesser curvature ulcers it is divided before the lesser curvature is reached.

Fig. 8. With stomach turned sharply to the left, the left gastric and gastro-epiploic vessels ligated, the posterior surface exposed, forceps are applied to the submucosal vessels before division of the full thickness of the stomach wall. The stomach is then opened between forceps and clamp.

tation of stomach contents toward the duodenum (Fig. 9).

Special care should be used to avoid making a spur where the greater curvature of the stomach meets the jejunum. A spur is all too easily formed here by unnecessary reinforcing sutures (Fig. 9).

If a Levine nasal tube has been introduced, it is now fished out of the stomach before the final closure is completed, drawn down 6 to 8 inches, and inserted distally into the jejunum. It permits the immediate introduction of liquids, if indicated.

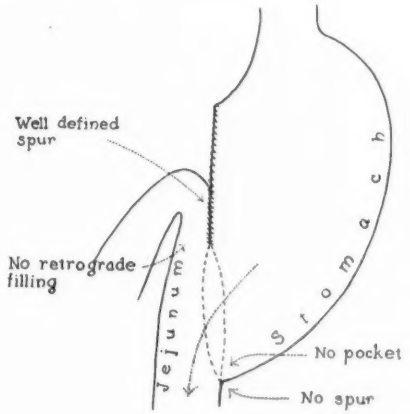

Fig. 9.

SUMMARY

Removal of the ulcer bearing segment of the stomach and duodenum is advocated as a routine procedure in resistant duodenal and gastric ulcers.

Such a resection aims primarily at the subtotal removal of the lesser curvature and the distal half or more of the stomach.

Spur formation at the lesser curvature border of the cut end of the stomach, the attachment of the jejunum so as to reinforce this spur, the attachment of the stomach close to the origin of the jejunum, and the avoidance of a spur at the junction of the greater curvature of the stomach with the jejunum, are regarded as necessary features in the technique.

These steps prevent retrograde filling of the duodenum with stomach contents.

TUMORS OF THE TENDON SHEATHS

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IT is customary to consider tendons in relation to their origin from the bellies of muscles; their insertion into bone and to their tendon sheaths. When tumors of the tendons and their sheaths are under consideration their relationship to bones and joints must be considered. The tendons, which blend with the fascia and aponeuroses of muscles at their origin, develop from fibrous tissue. The part of the tendon which is attached to bone or structure about a joint is derived from precartilaginous tissue, which is the same as that tissue which is concerned in the histogenesis of bone.

Malignant tumors rarely develop either in the fibrous portion of the tendon or from that developing from precartilaginous tissue. Benign tumors, on the other hand, are relatively common. These are practically confined to the tendon sheaths and to the tendons at their points of attachment. The most common tumors of the tendon sheaths are the osteochondromata, ganglions, and giant cell tumors or xanthomata. These correspond to tumors which develop from bone, for osteochondromata are usually considered as tumors of bone; ganglions correspond to the myxochondrosarcomata of the skeleton; and giant cell tumors of the long bones are frequently identical histologically with those developing in the tendon sheaths.

Osteochondromata and chondrosarcomata may develop at the point of insertion of any tendon, and usually these tumors are thought to have developed from bone. There are recorded in the Surgical Pathological Laboratory 262 cases of osteochondromata, 77 of primary chondrosarcomata, and 35 of osteochondromata undergoing malignant change have been analyzed in *Tumors of Bone* by Geschickter and Copeland. In many of these cases and especially in the benign tumors encountered in multiple exostoses, the new growth may extend for some distance along the tendon.

Not infrequently myositis ossificans begins in the tendons near joints. In the generalized progressive form of the disease, the ossificatio begins in tendons near their insertion in th vertebræ or ilium, and bone formation passe through a cartilaginous stage, which indicate the initial changes in the disease, begins in th portion of the tendon related in its develop ment to precartilaginous tissue (Fig. 1).

Both benign osteochondromata and chondrosarcomata may develop independent o bone just above the joint where the tendon i inserted, where precartilaginous tissue usually persists in the tendon. Seven benign osteochondromata definitely located in the tendon sheaths may be found in the Laboratory of Surgical Pathology. Reports of 15 other cases in which the tumor was so situated appear in the literature. One of these situated at the tibiotarsal joint in a child was reported by Lance. Patel reported a bilateral case in the tendo achillis. These interfered with walking. Beraud, in discussing this case, reported 2 other cases. Chevrier reported an osteochondroma in the biceps tendon, and Janik one on the dorsal surface of the right forearm. In addition to these 5 cases, Janik reported 2 more and cited 6 others (Buxton, Beck, Billroth, Chauvain-Roux, Delbet, and Pallailon). Ombredanne, in 1907, also reported a case. The tumor in the cases cited by Janik developed on the hand and foot in adults, and the histological diagnosis in most were chondromata. In Buxton's case the tumor developed in the flexor tendon of the ring finger. It was ossified and was of the size of a sesamoid bone. Buxton also described a case of multiple cartilaginous tumors attached to the tendons of the hand. This specimen is in the museum of King's College Hospital in London.

All the cases that we have seen were in adults. One occurred in the flexor carpi ulnaris above the styloid process of the ulna; another anterior to the ulna at the elbow. Three occurred in the tendo achillis; one in the quadriceps tendon above the patella; and another anterior to the ankle joint. There was no associated history of arthritis or tenosynovitis (Fig. 2).

Two chondrosarcomata of the tendons are recorded in the Laboratory (Fig. 3). Jones has reported a case of a chondrosarcoma of the quadriceps tendon associated with chondrosarcoma of the knee joint and exostosis. Button has described a chondrosarcoma which developed on both sides of the tendo achillis in a girl 17 years old. This specimen is preserved in the museum of the Royal College of Surgeons. The cartilage was derived apparently from connective tissue and in places had undergone ossification. In the benign tumors calcification and ossification appear beneath the capsule of the lobules. In the malignant cases cellular precartilaginous connective tissue is found in these areas.

The histogenesis of intracartilaginous ossification observed in long bones is repeated in these tumors—a transition from connective tissue to cartilage and then to bone. The tumors of the tendon sheaths develop from undifferentiated precartilaginous foci found within the sheath (Fig. 4).

Cartilaginous and osteocartilaginous non-neoplastic lesions are associated usually with osteophytes, developing in chronic arthritis and in cases of bursitis. These lesions give rise to some pain following repeated and excessive motion. Severe symptoms are rare unless trauma or infection occur. If such lesions take on rapid growth, a malignant change is suggested and wide excision practiced.

Ganglions of tendon sheaths. A ganglion is an oval, cystic tumor occurring in adults about the wrist, or ankle, or on the extensor surface of the wrist, or dorsum of the foot. Occasionally they are found about the knee joint, and rarely about the hip. Baumecker has reported 1 case and cited another about the hip joint. Borchordt has reported such a tumor in the tendon of the long head of the triceps some distance from tendon sheath or joint capsule. The ganglion contains many dilated spaces surrounded by connective tissue which contain jelly-like, translucent material. Usually the tumor is attached to the tendon sheath or joint capsule by a fibrous band. They do not communicate directly with the joint. There has been much discussion as to their nature and etiology since the time of Ellers (1746). At one time they were thought

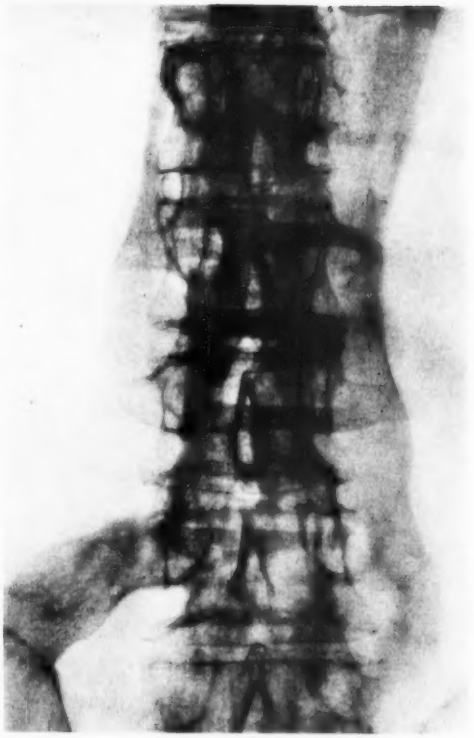

Fig. 1. Myositis ossificans progressiva with ossification of the ligaments and tendons and the spinal muscles. The patient was a white male aged 15 who had limitation of motion about the back since earliest childhood. Biopsy of the tendons at their insertion into bone showed that the ossification was proceeding via cartilage.

to be herniations of synovial membrane from the joint or tendon sheath. Clarke, in 1908, regarded these as neoplasms of connective tissue origin. This view has been generally accepted. They do not have a true endothelial lining. They present the same regressive changes that occur during embryonic life in the precartilaginous tissue during the formation of joint cavities and anatomical and adventitious bursæ in later life. Many of the ganglions found in unusual locations are probably adventitious bursæ.

Forty of these small tumors are recorded in the Laboratory and have been studied microscopically. All except five related to structures about the wrist. Four were found about the ankle, one at the knee. One occurred in a

Fig. 2. Osteochondroma in the tendo achillis of a white male aged 21. The patient has remained well without treatment or change in the condition during the past ten years.

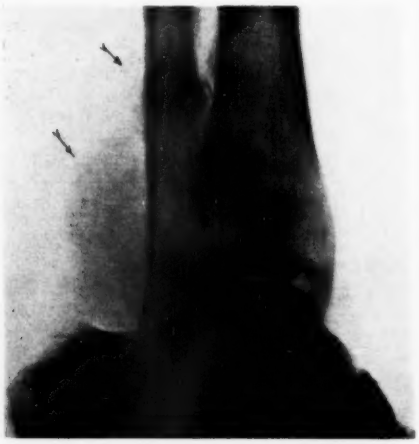

Fig. 3. Chondrosarcoma occurring in the tendo achillis in a woman of 31 years. There had been pain and tumor formation for 2 years at this site following an injury. The leg was amputated following a biopsy of the lesion. Chondrosarcoma with many fetal cartilage cells was found invading the tendon upon pathologic examination.

child of 2, another in a child of 11. The remainder occurred in adults.

Giant cell tumor of the tendon sheaths. There is considerable difference of opinion as to the origin and pathology of the very common giant cell tumor of tendon sheaths. Some have called these synovioma, endothelioma, myeloma, xanthoma, and granulation tissue tumors. Because of the relationship to sesamoid bones and because the tissue from which they develop is related to the skeletal blastema, we prefer the term giant cell tumor, or xanthomatous giant cell tumor of the tendon sheaths.

In a previous report from the Laboratory (Geschickter and Copeland, 1929) the literature was reviewed and 27 cases were added to the 144 collected by Mason and Woolston, making the total 171. Twenty-three additional cases have been studied in the Laboratory, and 6 other cases have recently appeared in the literature (Bessessen, Dudley, Ragins, King, Bellelli, and Jebens). In a recent review (King, 1931) the pathological relationship to other neoplasms of the tendon sheaths is discussed.

Thirty-two of the 50 cases recorded in the Laboratory were located in the sheaths of the tendons of the finger, at the metacarpophalangeal or interphalangeal joints, as a rule, on the flexor surface. The remainder, with few exceptions, were elsewhere on the hand, or about the foot and ankle. All the patients except 5 were adults, the majority being between the ages of 30 and 40 years. The youngest patient was a boy of 7 years. The tumors ranged in size from that of a pea to that of an adult's fist. The history, as a rule, extended over years. A review of our cases and those in the literature shows a definite relationship between these tumors and that of sesamoids observed in man, so carefully described by Pfitzner. The evidence, that sesamoids embedded in tendons are the point of origin of these tumors, is based upon histological study. In addition to phagocytic giant cells, foam cells, and blood pigment, these tumors contain fibrocartilage and occasionally bone. Many of the tumors in our series have a stroma of fibrocartilage; 3 contained bone. King also noted a frequent transition to cartilage and occasionally to bone.

Sesamoid bones develop from fibrocartilage and are frequently incompletely ossified.

Fig. 4. Photomicrograph showing the insertion of the normal tendons into bone from an arm of an adult, amputated for tumor of the hand. At the upper margin are shown normal bone spicules. At the lower margin the fibrous substance of the tendon is seen. Between is seen a transition from fibrous tissue to bone via cartilage.

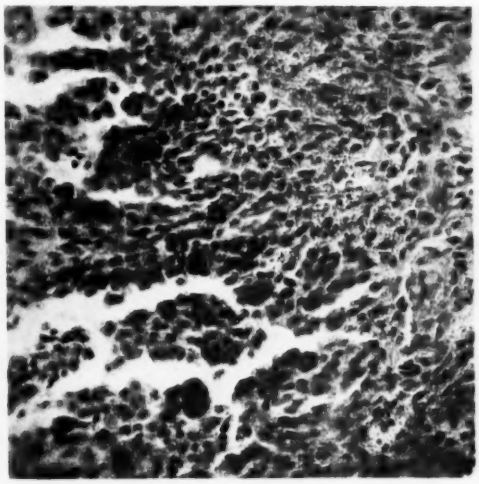

Fig. 5. Photomicrograph of a giant cell tumor of the tendon sheaths.

Following the phase of calcification, giant cell proliferation occurs, which is closely related to that occurring in the tumors under discussion. Study of the embryology and anatomy of the sesamoid bone supports the view that the majority of giant cell tumors of the tendon sheaths arise from sesamoid bones. Xanthomatous tumors are most apt to involve tendon sheaths, bursæ, and joints diffusely, and are less likely to recur after excision, or to invade bone, than true giant cell tumors, which may also contain cells of the xanthomatous type because of lipoid phagocytosis (Fig. 5).

Giant cell tumors of the tendon sheaths are usually small and benign. Two cases in our series recurred after removal; three invaded bone. Bessessen has reported a case on the middle finger of a man, aged 27 years, which recurred. Ragins found reports of 6 cases in the literature which invaded bone. Simple excision should be practiced.

Giant cell tumors of the patella. The patella is really a sesamoid bone. Giant cell tumors of this bone are much like those just described. Three cases of giant cell tumors of the patella are recorded in the Laboratory. Histologically they are like the giant cell tumor of tendon sheaths, and the same type of tumor occurring in the ends of long bones. Such tumors have been reported by Cole, King and Towne, and by Kraft. While giant cell tumors of the patella are not common, chondromata and cysts of this bone have been reported, showing that the same pathological changes may occur in the patella as in other sesamoids and tendon sheaths. Neurnbergk has collected 37 tumors of the patella, adding 2 of his own and 6 others which had not been reported.

Lipomata, fibromata, and fibrosarcomata of the tendon sheaths. Connective tissue tumors not related to precartilaginous and preosseous tissues are rare in tendons and tendon sheaths. Lipomata are more common in the synovial membrane of joints than in tendon sheaths. Strauss found 18 in the literature which were definitely connected with tendon sheaths. He quotes from Billroth, who first mentioned the possibility of these tumors in tendon sheaths. "In synovial folds and villi of the joints, as also in the tendon sheaths, there may be abnormal fat formation, so that the masses of fat seem to be branched like a tree (Mueller)." The majority of the cases are of the arborescent type, some simple lipomata; all are attached to the sheath. The majority of the patients are young adults who had had symptoms from 1 to 19 years. The

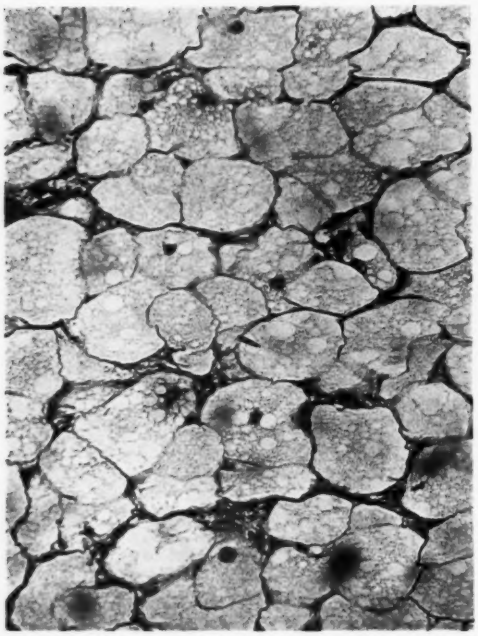

Fig. 6. Embryonic lipoma occurring in a tendon sheath about the knee joint. Large foam cells transforming into adult fat are shown.

extensor tendons of the hand and feet are most frequently involved. One case in which the extensor tendons of the forearm were involved was bilateral. There is nothing remarkable about the microscopic appearance of these lesions. They are typical lipomata. At operation a soft, fluctuant, lipoid growth is found which surrounds the tendon, which tunnels the folds of fat. The sheath must be excised with the tumor. Occasionally, a smaller lipoma has been reported projecting from the sheath. Recently Straus (F. H.) has reported a lipoma of the hand about the lumbricales on their dorsal side. Valdoni also reported the case of a male aged 19 years with bilateral lipomata affecting the tendons of the hand and feet. Those on the hand recurred after operation. Most of the villous growths of the tumor were attached to tendon sheaths, some were free.

There are only two recorded in the Laboratory. One of these was in front of the patella and not associated with a lipoma of the knee-

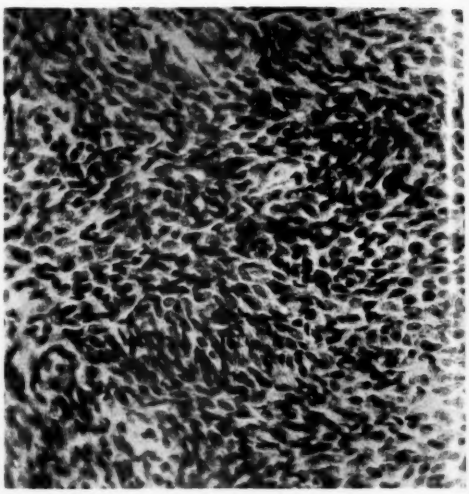

Fig. 7. Fibrosarcoma in the quadriceps tendon occurring in a boy of 9 years. There was a recurrence of the tumor following excision.

joint (Fig. 6). Another was in front of the elbow joint and surrounded the muscles and their tendons. No typical arborescent lipoma arising from the tendon sheaths of the hand or foot is recorded.

Fibromata of the tendons are as rare as lipomata. Buxton collected 13 fibromata from the literature. Torchiana recently reported a case in a woman aged 39 years who had a tumor in the palm of the hand which recurred after operation. The tumor was histologically a fibroma and involved the tendons of the third, fourth, and fifth fingers. Wright-Smith has also reported a case of a male patient 21 years of age who had a tumor of the tendon of the ring finger. This was on the flexor tendon, and a history that it followed trauma was given.

Four cases of fibromata are recorded in the Laboratory. One developed above and behind the clavicle in the anterior scalenus muscle. Another developed in a tendon on the dorsum of the hand; the 2 others occurred about the knee joint in the tendons of the semimembranosus and quadriceps. These tumors were definitely encapsulated and easily excised. Histologically, they resembled exuberant scar tissue, bundles of collagen and long connective tissue fibers staining heavily with eosin

being found. The cells were fairly tightly packed together, and the collagen made the tumor far more dense in the gross than nerve sheath tumors with which they may be confused.

Fibrosarcomata are probably the rarest of all tumors occurring in tendon sheaths. Many, formerly regarded as sarcomata, are now known to be the benign giant cell tumor. King presents a photomicrograph of a malignant spindle or mixed cell sarcoma. He does not give the history of the case. One doubtful case is reported by Krogius, which recurred. This tumor occurred in a woman of 21 years of age. It developed in the sheath of the flexor longus hallucis. It recurred and in the recurrence xanthoma cells were found. Recently Cooperman has reported a tumor which developed 2 months after an injury. It became as large as an egg and occurred in a female patient aged 21 in the flexor tendon of the little toe of the right foot.

Five primary sarcomata of the fascial type involving the tendons and tendon sheath are recorded in the Laboratory. All these were in children or young adults. Two occurred in the quadriceps tendon and were located laterally or beneath the patella (Fig. 7). One was in the tendo achillis; another anterior to the ankle joint, and the fifth above the phalanx. All of these tumors were dense, firm, and composed of closely packed, small spindles. All of these recurred after primary excision. Two of the recent cases were irradiated, without results. The follow-up on these patients showed death with metastases in two instances. The other patients could not be traced.

CONCLUSIONS

Among neoplasms of the tendon, benign osteochondromata, ganglions, and giant cell tumor or xanthomata predominate. These tumors show a relationship to precartilaginous tissue. Fibromata and lipomata also may occur. Tumors of the tendon proper and sarcoma are rare. Chondrosarcoma at or near the insertion of tendon into bone, and fibrosarcoma of the tendon sheath are two rare forms of malignancy found in these structures.

BIBLIOGRAPHY

1. Baumecker, H. A case of ganglion in the region of the hip joint. Beitr. z. klin. Chir., 1930, cl, 490.
2. Beck. Cited by Janik.
3. Bellelli, Francesco. Tumor of the tendon sheaths. Riforma med., 1932, xlviii, 630.
4. Bessessen, Daniel H. Xanthoma, so-called giant cell tumor of the tendon sheath. Western J. Surg., 1930, xxxviii, 701.
5. Beraud. Cited by Patel.
6. Billroth, T. "Sehnenscheidensarkome." Chir. Klin. in Wien., 1868–1869. Quoted by Tourneux.
7. Buxton, J. D. Brit. J. Surg., 1923, x, 40.
8. Chauvain-Roux. Bull. et. Mém. Soc. anat. de Par., 1920, xc, 192.
9. Chevrier. Synovial fibrochondromatosis of the biceps tendon. Bull. et Mém. Soc. Nat. de Chir., 1932, lviii, 565.
10. Clarke, W. C. Pathogenesis of ganglia. Surg., Gynec. & Obst., 1908, vii, 56.
11. Cole, W. H. Primary tumors of the patella. J. Bone & Joint Surg., 1925, vii, 637.
12. Cooperman, M. B. Spindle-cell sarcoma of tendon sheath. J. Bone & Joint Surg., 1932, xiv, 173–176.
13. Delbet. Cited by Janik.
14. Dudley, Homer D. Giant-cell tumors of tendon sheaths. Northwest Med., 1930, xxix, 217.
15. Ellers. Cited by Clarke.
16. Geschickter, C. F., and Copeland, M. M. Tumors of Bone. Am. J. Cancer, 1931.
17. Janik, A. Tumors of the tendon sheaths. Ann. Surg., 1927, lxxxv, 897.
18. Jebens, E. Henrietta. Myeloma of tendon sheath. Proc. Roy. Soc. Med., 1932, xxv, 1089–1099.
19. King, M. J., and Towne, G. S. Primary giant cell tumor of the patella. Arch. Surg., 1929, xviii, 892.
20. Kraft, E. Giant cell tumor of the patella. Radiology, 1931, xvii, 1049.
21. Krogius, A. Acta. chir. Scand., 1922–1923, lv, 363.
22. Lance. Congenital exostoses and an osteochondroma of the tibio-tarsal joint. Rev. d'orthop. et de chir., 1931, xviii, 335–339.
23. Mueller. Cited by Billroth.
24. Neurnbergk, H. Osteitis fibrosa of patella. Beitr. z. klin. Chir., 1931, cliii, 406.
25. Pallailon. Cited by Janik.
26. Patel. Osteoma developing in the tendo achillis. Lyon Chir., 1931, xxviii, 351.
27. Pfitzner, W. Die Sesambeine des Menschen. Morphol. Arb., 1892, i, 517.
28. Ragins, Alex. B. Benign tumors of the tendon sheaths of unusual size. Ann. Surg., 1931, xciii, 683.
29. Straus, F. H. Deep lipomas of hand. Ann. Surg., 1931, xciv, 269.
30. Strauss, A. Surg., Gynec. & Obst., 1922, xxxv, 161.
31. Wright-Smith, R. J. Fibroma of tendon sheath. Australian & New Zealand J. Surg., 1931, i, 106.

THE PRESENT STATUS OF THE SURGICAL TREATMENT OF PEPTIC ULCER[1]

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IN spite of the fact that the etiology of peptic ulcer is still unsettled, we now have several methods of treatment that are satisfactory when properly applied to the condition for which they are appropriate.

It has never been difficult to produce an acute ulcer of the duodenum experimentally, but only in comparatively recent times has it been possible to produce a chronic ulcer at will. This has been accomplished by Mann, Dragstedt, and others. It has long been realized that the concentration of free acid in the stomach is an important factor in the etiology of the condition, but that variations in the concentration of the acid did not explain the whole situation. Recently, Matthews and Dragstedt concluded that the chemical action of pepsin hydrochloric acid is the outstanding factor in the production of acute and, subsequently, chronic peptic ulcer, although gastric motility, trauma to the mucosa, and general systemic conditions help to promote the progress of the process. It is also known that some individuals are particularly prone to the development of ulcer and that heredity possibly plays a part. In some instances, infection or toxins may exert considerable influence. Wilkie lays much emphasis on irregular habits of living.

Certainly any logical treatment of this condition, whether medical or surgical, must be directed toward correction of the recognizable factors in the etiology of the disease. The choice of treatment for duodenal ulcer depends on the duration and severity of the symptoms, the extent and type of the lesion, and the age and temperament of the individual.

Under some circumstances it is permissible to give medical treatment a trial, provided the patient can be kept under close observation, but the measure of success to be derived from this plan depends upon strict attention to detail. Furthermore, there is a particular type of patient who usually obtains more benefit from this regimen than from any other. He is the nervous, high-strung individual whose history usually discloses that the symptoms are exaggerated by even a slight increase in nervous strain. Experience shows that even though it may be possible to accomplish healing of the ulcer he is prone to have a recurrence of the lesion regardless of the method of treatment. For this reason, any operation that may be employed will give unsatisfactory results. The best that we can hope to accomplish for these patients is to keep the symptoms under control a part of the time. It has also been recognized that the results of surgical treatment of peptic ulcer in very young individuals is often not completely satisfactory. There is still another group of patients in which repeated courses of medical treatment will be the most logical plan. They present symptoms that are more or less typical of ulcer, yet the laboratory tests fail to confirm the presence of the lesion. If surgical treatment is finally demanded in these cases, it should be confined to the local operation, that is, to removal of the cap of the duodenum together with the ulcer and the anterior two-thirds of the pyloric sphincter muscle, making closure as a gastroduodenostomy. Gastrojejunostomy is most unsatisfactory in this particular type of case. If there is perforation, obstruction, hæmorrhage, or a history of progressive recurrent symptoms, in spite of well controlled medical management surgical treatment is indicated.

The first operations were carried out for the relief of obstruction. The Billroth I procedure and gastro-enterostomy were first used in 1881 to overcome obstruction due to malignancy, but were soon employed for the treatment of benign lesions. In 1885, the Billroth II operation was introduced. A plastic operation on the pylorus was carried out by Heineke in 1886. Mikulicz, working independently and without knowledge of Heineke's work, devised a similar procedure in 1887. In 1891, Kocher

[1] Read at the Chicago Surgical Society, Chicago, February 2, 1934.

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performed an end-to-side gastroduodenostomy following pylorectomy. To Jaboulay is attributed the first suggestion of the possibilities of lateral gastroduodenostomy in 1892. The first clinical application of this was made by Henle, in 1898, and he gave Mikulicz credit for the plan. Finney stated that his gastropyloroduodenostomy, better known as Finney's pyloroplasty, was an outgrowth of that work. Gastrojejunostomy remained the procedure of choice because of the ease of application and the high percentage of satisfactory results that could be obtained. But the incidence of jejunal ulcer later made it apparent that this procedure was not applicable to all cases.

The experience of European surgeons influenced the growing popularity of partial gastric resection for duodenal ulcer. Then followed a great variety of modified Billroth I and Billroth II operations. Von Haberer, in 1922, and Finney, in 1924, working independently, advocated end-to-side gastroduodenostomy following pylorectomy and partial duodenectomy. Others were using the Pólya type of resection of the stomach. Partial gastric resection was advocated and carried out on the theory that it removed the acid-bearing and ulcer-bearing portions of the stomach. More recent studies show that the acid-producing cells are situated in the fundic portion of the stomach, which, of course, nullifies the argument for this radical procedure. And it is also realized that in this country we do not encounter the same type of lesion that the European surgeon has to contend with, the ulcer with an associated extensive gastritis. The lesion that occurs in patients in this country does not justify the adoption of the radical operation employed by the European surgeons. In our experience, there is possibility of recurrence of the lesion even after such resection, and the radical operation makes further surgical treatment difficult and hazardous. It is probable that resection of the greater part of the stomach does not afford any better protection against stomal ulcer than the simple gastrojejunostomy.

In an effort to find a procedure that would leave the upper digestive tract in a condition more in keeping with its normal anatomy and physiology, numerous plastic procedures on the pylorus have been devised. In the first place, it seemed reasonable to expect that removal of the lesion itself would give some added advantage in the control of the pathological process, but this alone was not sufficient. Elimination of the action of the pyloric sphincter was recognized as necessary in order to relieve spasm, which causes persistence of symptoms in many of the cases. Removal of the cap of the duodenum with the ulcer and the anterior two-thirds of the ring of the pyloric sphincter not only extirpates the lesion but also eliminates all possibility of spasm due to sphincter action. Closure is then made by gastroduodenostomy, which re-establishes the normal continuity of the gastro-intestinal tract. Exposure for this operation is not difficult, if it is not attempted in cases in which the ulcer is at some distance from the pylorus or in which the duodenum is too firmly fixed to be readily mobilized. This operation is applicable in at least 50 per cent of all cases of duodenal ulcer.

In the cases in which the duodenum can not be mobilized without undue risk and in which it is not feasible to do a gastrojejunostomy, it has been found that a satisfactory lateral anastomosis can be made between the pyloric end of the stomach and the first portion of the duodenum, the pyloric muscle being left undisturbed. Wilkie has used a somewhat similar gastroduodenostomy, except that the second portion of the duodenum is employed in making the anastomosis, thus leaving the first portion of the duodenum looped above the anastomosis. The procedure has been criticized because it permits retrograde flow of the gastric and duodenal contents over the ulcer. By making the anastomosis in the first portion of the duodenum, just below the ulcer, this situation is obviated. It is true that the ulcer has not been removed, but under the conditions that are imposed by the procedure, the lesion heals quite readily. Wilkie reported satisfactory results from lateral gastroduodenostomy in 89 per cent of the cases that he observed from 1 to 12 years. A stomal ulcer occurred in only 2 cases; in these the operation apparently had no effect upon the lesion or

upon the symptoms produced by it, although the gastric acidity had been lowered.

In a review of our cases in which lateral gastroduodenostomy was performed 1 to 10 years ago, in only 1 case was an unsatisfactory result reported; this patient found that he had to adhere to a modified ulcer regimen with the occasional use of alkalis. In all cases in which lateral gastroduodenostomy was performed, there was satisfactory immediate convalescence. This procedure is perhaps of greatest use in cases in which it is necessary to take down a gastrojejunostomy following the formation of a jejunal ulcer and in which the lumen of the duodenum is inadequate because of old scar tissue. Excision of this old scar with the anterior portion of the pyloric sphincter muscle would be desirable, but it is often impossible because of the fact that the duodenum is firmly bound down. It is not necessary to have a mobile duodenum in order to perform this type of lateral gastroduodenostomy. Furthermore, the risk of the procedure is minimal.

A review of operations performed at the clinic during the past year for duodenal ulcer shows an increasing proportion of pyloric procedures in comparison with gastrojejunostomies, about 1:2. In less than 5 per cent of all of the cases was it necessary to carry out a gastric resection. This shows the attempt that is being made to maintain the normal physiological condition and to avoid the radical procedures which, in the light of our experience, seem unjustified and, many times, turn out to be unsatisfactory. For older patients with marked obstruction but without excessive gastric acidity, gastrojejunostomy still remains the procedure of choice in most instances. In other cases, local excision of the lesion with the anterior two-thirds of the pyloric sphincter muscle offers the best chance of relief, whenever the operation can be carried out.

We feel that it is best to treat gastric ulcer as a surgical problem. We are willing to grant that gastric ulcer may likewise be made to subside by a medical regimen, but we still contend that it is impossible to distinguish between the benign and malignant gastric ulcer without an opportunity to study tissue of the lesion microscopically. If it were possible to have all patients with gastric ulcer under close observation at frequent intervals, we might feel justified in offering a trial of medical management in those in which we have reason to feel the lesion is benign. There is no question but that the symptoms resulting from gastric ulcer can be relieved more readily through this plan than are those of duodenal ulcer. For a number of years we have recommended surgical treatment to practically all patients with gastric ulcer, but it should be stated that, when we carry out the operation, it is a conservative plan of procedure. Some of the most satisfactory results that we have obtained in the treatment of gastric ulcer have followed this plan of caring for the condition: usually a V-excision of the lesion combined with gastrojejunostomy. In these cases, the operation is practically never followed by the formation of a stomal jejunal ulcer, which is the bug-bear of operations for peptic ulcer. In some instances, when operating for gastric ulcer, the technical procedure is simplified by taking out the pyloric part of the stomach with the ulcer, and we have also used this method.

The more we study the problem of peptic ulcer, the more we are impressed with the fact that an ulcer in the stomach imposes a problem very different from that of ulcer of the duodenum, from an experimental standpoint as well as from the clinical and the surgical standpoint.

Finally, it may be stated that we believe that some of the problems associated with peptic ulcer are worked out. From meager beginnings 50 years ago to the present time, the efforts directed toward the treatment of peptic ulcer have met with a constantly increasing measure of success. As yet we have no single procedure that is applicable to all cases, but we do have well established plans of treatment of proved worth; these are rational conservative measures and, when properly carried out in the treatment of the conditions for which they are intended, they afford satisfactory relief from the distressing syndrome of peptic ulcer.

It is known that there are some patients who have a stronger potentiality for ulcer

than others. The best that can be accomplished for these individuals is to modify their symptoms through a restricted regimen so that they will be able to carry on their ordinary daily routine of activities.

The tremendous amount of experimental work that has been done on the ulcer problem all tends to show the importance of the concentration of the acid as a factor in the production and persistence of the ulcer. While recognition of this feature gives us something to work upon, it does not at present offer as much assistance as we should like in the control of the acid factor.

We have two procedures which remove more of the recognized etiological factors than the others: lateral anastomosis between the stomach and the first portion of the duodenum, and excision of the cap of the duodenum with the lesion and the anterior two-thirds of the pyloric sphincter muscle, with closure as gastroduodenostomy. We think that these procedures have more of a physiological basis and that they are more practical than any anastomosis between the stomach and the jejunum. There is wider distribution of the food stream and reduction of physical trauma, the stomach empties more rapidly, and the gastric pressure is lowered. In addition, the acid contents of the stomach are emptied into the most alkaline portion of the duodenum which is best fitted to care for this acid medium. Furthermore, the alkaline duodenal content may easily be regurgitated into the stomach. These two operations should be employed more often.

REFERENCES

1. FINNEY, J. M. T. The surgery of gastric and duodenal ulcer. Am. J. Surg., 1926, 1, 323–343.
2. MATTHEWS, W. B., and DRAGSTEDT, L. R. The etiology of gastric and duodenal ulcer; experimental studies. Surg., Gynec. & Obst., 1932, lv, 265–286.
3. WILKIE, D. P. D. Indications for surgical therapy in peptic ulcer. Brit. M. J., 1933, 1, 771–774.

THE PROBLEMS INVOLVED IN THE TREATMENT OF COMPOUND FRACTURES

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THE increasing number of compound fractures that are occurring in this machine age and the divergent opinions among teachers and writers relative to the basic principles involved in their treatment impels one to believe that there is a real need for a wider discussion and a better universal agreement as to what constitutes the most approved methods of caring for these frequent and serious conditions.

It is thought by some that the radical variance of opinion regarding the treatment of compound fractures is due in a large measure to the advent of the orthopedists into this field of endeavor, for by tradition and training they are not operating surgeons and the care of these cases requires broad surgical experience and judgment. The orthopedists, however, should be welcomed into this department of surgery, the treatment of fractures, for they have added and will continue to add much to our knowledge of the entire subject. They are becoming operating surgeons.

The circumstances in the practical situation are such that the larger number of compound fractures are seen first and frequently cared for by general practitioners, and this group of men are expecting the teachers and the men with the opportunities for the observation of a large number of these cases, to draw deductions and conclusions regarding the best methods of procedure for their guidance. The course must be charted for them.

A compound fracture as a surgical entity must be considered first from the pathological standpoint. Correct treatment cannot be applied without an intimate knowledge of the anatomical disturbance and an appreciation of the immediate and remote histopathology resulting from the injury.

The fracture itself is frequently of secondary importance to the trauma inflicted upon the soft tissues. Nerve, blood vessel, muscle, and tendon injuries may demand the essential consideration in the question of treatment.

Formerly a larger proportion of compound fractures occurred in railroad accidents and from contact with heavy machinery. In these cases the crushing of the soft tissues was more extensive than it is in the many automobile injuries which are seen so frequently at the present time. In any consideration of the pathology of the fragments of the fractured bone itself, it may be stated broadly that, except for the potentialities of infection, the condition is not materially different from that in simple fractures.

The mechanism of the injury to the soft parts and the opening of the skin is important, for in the cases compounded from within outward, infection is less apt to occur and the integrity of the circulation of the soft structures is less interfered with. In a word, there is less crushing of tissues. The question of the pathology concerned in compound fractures, from the standpoint of the surgical therapy that shall be applied, resolves itself into a consideration of the circulation in the injured structures and their subsequent viability. Obviously, our main objective is to convert a compound fracture into a simple one and this can be accomplished only if, and when, we succeed in preventing infection and subsequent suppuration. Devitalized tissue offers no resistance to infection and must therefore be removed by the most careful and painstaking excision. It is rather elementary to recall how rapidly organisms on the surface extend through the lymphatics to deeper tissues and to the neighboring lymph glands, and yet an understanding of this is most essential in the treatment. Fascia and tendinous tissue having poor circulation are prone to sloughing when infected.

The muscles are apt to be our chief concern because of their size and proximity to all fractures, but, fortunately, their viability can be determined more easily than that of other tissues. Devitalized muscle is gray in color, it does not contract when picked up in a

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forceps, and it does not bleed when cut. It is difficult to ascertain accurately the amount of blood supply in injured nerve tissue or tendon, and in an estimation of their viability one must depend upon their general appearance. In any attempt to determine the amount of injury to the tissues that may subsequently be encountered careful examination should be made of the larger blood vessels supplying the distal parts.

In a large proportion of instances compound fractures occur during accidents on the highways or on railroads and the problem of transportation to the nearest hospital is of first consideration. The Fracture Committee of the American College of Surgeons have made real progress in their practical teachings of the necessity of splinting all fractures before transportation so that the fragments will not do further damage. This point applies in particular to compound fractures. Much can be accomplished by teaching first aid to all men who are likely to come in contact with these cases. In so far as practical, the Thomas leg and arm splints should be provided. The Fracture Committee have gone into this subject most thoroughly and are enlarging their educational program.

When the patient reaches the hospital he is usually in a state of shock more or less severe and this condition demands our first attention; almost without exception morphine should be administered immediately as the best agent to stop pain and thus aid materially in preventing further shock. Active hæmorrhage should be looked for and checked at once. All constrictors must be removed as soon as feasible. The degree of the shock must be determined and if severe no operative procedure should be considered until this is overcome. Many fatalities occur as a result of too early operation. Our first duty, therefore, should be to alleviate shock and any operative interference should be postponed until recovery from this primary condition has taken place. Morphine, external heat, hot coffee per rectum, hot drinks, and blood transfusion when indicated offer the best agents with which to combat shock. The subcutaneous or intravenous injection of normal salt solution should not, in our judgment, be done. Gum acacia or other similar preparations should not be given intravenously for they are of questionable value. It is appreciated that these are rather broad statements especially as regards salt solution and may cause controversy but they are our conclusions based on a rather large experience in Cook County Hospital, Chicago, and in France.

As soon as the patient rallies from shock, the injured limb should be given our immediate attention, for the time element between the receipt of the injury and the treatment of the wound is most important. Almost without exception operative interference is indicated. It is assumed that head, chest, abdominal, or other injuries do not preclude operation on the limb.

The choice of anæsthetic must depend upon the judgment of the individual operator, although it is our conviction that no single method should be employed routinely for every case. Nitrous oxide and oxygen, and ether by the drop method are preferable. Possibly, spinal anæsthesia is desirable for thigh injuries in the hands of those accustomed to its use.

Continuing the question of the treatment, let us assume that the circulation of the distal part is such that the necessity for immediate amputation has been excluded. With the patient asleep the problem of cleansing the wound confronts us. Water and green soap are used, following shaving, for cleansing the surrounding skin. This is done after protecting the wound with gauze. After the skin is prepared with soap and water, ether is used to remove all grease and other soiling.

Then comes the question of the choice of antiseptics, if any are used. Does not the multiplicity of the antiseptics now in use condemn them all as dependable agents? We believe it does. Some antiseptics may be capable of destroying organisms on the surface but they serve no useful purpose in attacking the bacteria deep in the structures and we are convinced that most of these so called germicides further lower the resistance of the almost devitalized tissue when applied in sufficient quantity and concentration to be of any value. They should not be relied upon

as safeguards against ensuing infection. However, as a routine practice after the skin is cleansed with shaving, soap and water, and ether, we use 5 to 7 per cent tincture of iodine liberally in the wound and wash it out with alcohol. Is this consistent? We feel that tincture of iodine is the safest and most reliable germicide and least harmful when seeking the sterilization of the superficial structures. Such treatment may protect the instruments from contamination in the handling of these tissues. Iodine is never used in the presence of an open joint.

Stated briefly, we must rely and depend upon mechanical and not chemical cleansing of these wounds. The question that arises is, do we remove or destroy all of the bacteria in the wound? We do not, and our hope of healing by first intention is based on the removal of all tissues not capable of resisting the invading organisms. To this end a most complete débridement must be performed. This requires an experience in the observation of the macroscopic appearance of devitalized tissue. To accomplish this excision of non-resistant tissue requires time and painstaking search. It is our practice to remove a thin layer from all of the skin edges together with a small amount of the underlying fat. The removal of the devitalized muscle tissue usually constitutes the larger amount of the débridement. If the skin opening is small, it must be enlarged by incision until all of the crushed and contaminated tissue is exposed to vision so that careful excision may be accomplished. All of the exposed muscle must be excised to a point where it is red in appearance, bleeds when cut, and contracts when picked up with a forceps. These are the criteria by which we distinguish live, resistant muscle. Severed nerves and tendons must be sought for and sutured. The nerves are sutured with fine silk in a smooth sewing needle and the sheath of the nerve only is penetrated with the needle and the fibers are thereby thus approximated without injury to the nerve substance.

If there is extensive comminution of the fragments and small pieces are completely separated from the shaft of the bone and from their periosteal attachments, then it is deemed wise to remove them. Larger and attached fragments which seem capable of regeneration are left unless it is evident that they are badly contaminated from contact with the earth. When the ends of the larger fragments show evidence of any soiling it is our practice to remove a small portion of such bone with a large rongeur forceps, again adhering strictly to the principle of depending upon mechanical and not chemical cleansing of the involved tissues. At this stage in our technique comes the question of internal splinting and in our opinion it is deemed inadvisable to use any sort of non-absorbable material. We feel that the introduction and application of wire, Lane's plate, the clamp or ferrel is an error, for none of these methods can be applied without the danger of interference with the blood supply of the fragments in which the circulation is already damaged. The thoughtful consideration of the circulation in all of the injured tissues in compound fractures is most essential and fundamental.

At this point in our procedure all bleeding vessels should be controlled and the muscle and fascia when severely lacerated and separated, closed with catgut sutures with as little tension as possible. Having completed in a thorough and painstaking manner the débridement and the restoration of the continuity of any severed nerves or tendons and securing hæmostasis, we are confronted with the closure of the skin.

A discussion of this part of the surgical procedure involves the practice of using any kind or form of drainage. May we present for consideration the firm opinion and the unqualified conviction that compound fracture wounds should never be drained with any form of drainage material.

The substantiation of this argument is not applied upon the hope that it is correct, but is based on a large experience with ample control.

During our first year in France practically all wounds coming from the front to the base hospitals were drained and usually packed with all sorts of so called germicides, including Carrel-Dakin solution, the famous B. I. P., dichloramine-T, and many other red, white, blue, green, and yellow solutions, all short

lived favorites which lost their popularity rapidly. They did not withstand the test of time. During this time in France when wounds were drained, it is not recalled that we ever saw a clean non-infected wound. In 1918 all of this was changed and débridement was practiced extensively in the advanced stations and following this procedure many of the wounds were closed without drainage, and later under observation in the base hospitals they remained clean. Then we began to experience the satisfaction of seeing compound fractures converted into simple fractures and recover without suppuration. The accuracy and completeness of the skin suture must depend upon the loss of superficial tissue substance and the circulatory integrity of the remaining skin flaps. Obviously, any portion of skin that is thought completely deprived of all of its circulation must be sacrificed. Generally, it is not good practice to undermine the edges of the skin to overcome tension. Occasionally, it is feasible to make longitudinal incisions a distance from the edges to facilitate their apposition. The sutures should always be tied loosely and at some distance apart so as to allow the escape of fluids that might collect and cause considerable tension. A thought that the collection of serum may act as a germicide has been advanced. Where the skin has been so destroyed as to preclude the approximation of the edges a full thickness flap may be implanted over a small area. If it is found impossible to secure by any means an entire skin covering, it is our practice to apply a dressing of equal parts of alcohol and glycerin. This dressing is hygroscopic and tends to promote the flow of lymph toward the surface—a process thought to be beneficial.

We are in accord with the older school of thought which teaches that the long muscles of the extremities immediately contract and subsequently retract when a bone or bones are fractured. Following this conception we always apply skeletal traction to the distal part, and this is usually accomplished by means of some form of caliper or bone clamp. Kirchmer's wire or some other device may be used. The caliper in some form seems preferable for it does not penetrate the substance of the bone and is more easily removed. However, this may be decided by the choice of the individual surgeon. Plaster-of-paris splints or casts are rarely used. Perhaps they have a function in selected cases. Dependence is placed upon suspension splints, preferably some type of Thomas splint or the various modifications. New splints are being constructed by men of ingenuity and many of them have merit but give the best results in the hands of their designers. This is a technicality that is not important if the principle of skeletal traction is carried out.

The danger of tetanus and Welch bacillus infections in compound fractures is common knowledge, and a prophylactic dose of antitetanic and anti-Welch bacillus serum should be given as routine practice.

An attempt has been made here to give the principles of a routine method for the treatment of compound fractures of all kinds. If some of the statements seem dogmatic may we say that they are predicated upon a rather wide experience and advanced with a knowledge that any broad assertions about the surgical therapy best adapted for these cases, must be qualified by the admission that each injury has particular conditions with which to deal and is a law unto itself.

SUMMARY

1. All fractures must be splinted before transportation when this is practical.

2. The first procedure must consist of efforts to combat shock.

3. Débridement must be depended upon to cleanse the wound—mechanical and not chemical sterilization.

4. Careful search should be made for all severed nerves and tendons and repair accomplished.

5. Perfect hæmostasis must be secured.

6. It is imperative that all drainage materials be completely avoided.

7. The skin edges should be accurately approximated when possible.

8. Skeletal traction should be applied for the retention of the fragments in anatomic apposition.

9. Suspension rather than plaster-of-paris splints should be used.

ADEQUATE BACTERIOLOGICAL SERVICE FOR A SURGICAL DEPARTMENT

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THE era of modern surgery is hardly more than half a century old. It began within the life-time of many of the leaders of our profession and within the span of the professional careers of those older practitioners who are reaching the years of retirement and reminiscence. In another decade we shall no longer be able to hear the tales of surgical practice before the days of Pasteur and Lister. Modern surgery is founded upon certain bacteriological laws and its scope would have remained greatly limited if it had not made practical application of that biological knowledge out of which also grew the science of bacteriology. The discovery of these laws we owe to Pasteur. Their practical application to surgery we owe to Lister. Pasteur discovered that infection of wounds is caused by bacteria and Lister demonstrated that these bacteria may be destroyed by appropriate means and that the infection of operative wounds may thus be prevented.

One would have supposed that the science and art of modern surgery, having established itself on these basic bacteriological laws, would have continued to be intimately wedded to the science of bacteriology so that they might have grown up together to their mutual benefit; but such is not the case, for in most hospitals and in many medical schools, they have been completely divorced. Each goes its own way with little or no recognition of the other and with little or no attempt at mutual aid. If you should ask the chiefs of the surgical staffs of our hospitals, or the professors of surgery in our medical schools if they have anyone in their departments particularly interested in bacteriology, or if you should ask the professors of bacteriology if they have anyone in their departments particularly interested in surgery or surgical problems, the answer, in the majority of cases, would be "No." This is not true of the departments of medicine, for in most hospitals and medical schools the members of the bacteriological departments are often particularly interested in medical problems. Very often the head of the department of medicine is an expert in infectious diseases, and those members of his staff who are interested in bacteriology equal in numbers and rank those interested in the metabolic disorders.

One is tempted to ask why this should be so. Is there a larger proportion of infectious diseases in medical practice than in surgical practice? This may be true, but if this is a factor I doubt if it is the important one. The practice of surgery requires a large proportion of time to be given to certain technical training which the medical man does not need. Likewise the surgeon must devote longer hours to the detailed study and to the frequent review of anatomy. For many years many young surgeons considered it a necessary part of their training to teach anatomy. The next requirement for the surgeon is to know pathology. In this respect he does not differ from the medical man although it may be said that the surgeon more often has an opportunity of studying the pathology of his cases because such examinations can be made in all of his cases, those which survive as well as those which die, while the medical man's pathological study is limited to those cases which go on to a fatal termination of the disease. What time has a surgeon left to study bacteriology or be interested in it? The obvious answer is—"None, he must depend upon the bacteriologist to do his bacteriology for him." But can a bacteriologist, without knowledge of surgery, give adequate service to the surgeon either for routine or for special work? This question must be asked of the head of the surgical service or department: "Are you satisfied with the service the bacteriological department is giving you?" If we meditate upon this question, it becomes evident that this service must be fourfold: (1) routine, (2) emergency, (3) special minor research, and (4) major research.

THE PROBLEM

Routine work. In the first place there is a great mass of routine service to be rendered—the periodic check-up of the operating room technique—the autoclaves, the instrument sterilizers, the water sterilizers, the antiseptics, the catgut; the ward dressing technique; the cultures of infected wounds, abscesses, carbuncles, empyemas, sore throats, urine, and other material obtained from the daily run of operative cases and ward dressings. This work is perhaps the easiest to handle. It can be done in the course of the day's work from nine until five and a large mass of material may be handled at the same time.

Emergency work. In the second group, which is perhaps more important, there is a great quantity of work which might be called emergency bacteriology. This must be done on short notice at any time of the day or night. A patient comes into the hospital with peritonitis. The surgeon operates and finds a large amount of free peritoneal fluid without any evident perforation of the gut. He should know as soon as possible the nature of the infection. A smear and an immediate examination of the stained slide must be made while he is still operating and cultures must be made at once so that he may know within the time of brief incubation the organisms involved. Or a patient comes in with a compound fracture and after it has been set up with the proper traction and suspension apparatus, suddenly in the middle of the night the temperature goes up and the patient complains of pain in the wound. It is found to be swollen, œdematous, a little dusky. There is doubtful crepitation of the tissues. The surgeon must know promptly from smear and culture whether the gas bacillus is on a rampage and which of the four varieties is present. A patient has been operated upon for a pyloric obstruction, a gastro-enterostomy has been done; cough and hiccough are annoying postoperative complications. Suddenly in the night he develops pain in the wound. An examination reveals puffiness and crepitation beneath the wound. The surgeon must know at once whether a gas infection has developed or gas from a perforation or leak has appeared in the wound. A quick bacteriological examination is necessary. A patient comes in with a high fever, he is obviously septic, the focus is not apparent but it is important to know as soon as possible whether or not the patient has a positive blood culture. A patient is admitted to the hospital with high fever and a swollen, painful, red, hot knee-joint. The surgeon aspirates the fluid and needs to know the nature of the infecting organism by smear and culture. Any delay will materially affect the promptness of treatment and the eventual outcome. A patient is admitted with signs of fluid in the chest, aspiration reveals a thin, turbid fluid. Is it transudate or exudate? What bacteria are present? The correctness of treatment depends upon the prompt answer to these questions. Is your bacteriological department prepared to give you this emergency service at any time of the day or night?

Special bacteriological minor research. Frequently a patient comes into the hospital who presents an unusual problem in surgical infection. It may be an unusually severe type of a well recognized infection, or a rare type not easily recognized. The case obviously needs some special bacteriological study. Routine methods of taking specimens or routine methods of cultivation will not suffice. The preliminary culture may reveal no organisms in a lesion which is obviously an infection, or it may reveal an unusual organism with peculiar properties which require further study or it may yield a mixture of organisms, only one of which is significant. Such problems come up in severe cases of septicæmia in which not only the diagnosis must be made but the course of the disease must be followed from day to day. Serious involvement of the face and neck following the spread of an infection from teeth, tonsils, or œsophagus require this special kind of bacteriological service, for here we may have a mixture of mouth organisms and the severity of the infection may be due not so much to any single species of organism present, as to the synergism of the various species. Such complex problems likewise arise in cases of acute or chronic infective gangrene of the skin and these may have to be handled not only by means of a special bacteriological analysis but they may require

a series of animal experiments before the nature of the infection can be determined and the problem satisfactorily solved. Cases of lung abscess or bronchiectasis require a complete bacteriological analysis before they can be intelligently handled. Liver abscesses frequently need to be studied from several different angles before the cause can be determined and the appropriate treatment applied. Chronic ulcers of the abdominal wall or of the extremities often present difficult bacteriological problems which cannot be solved by simple procedures. Certain extensively infected wounds with loss of substance such as were seen frequently in time of war and occasionally occur in cases of accident, require not only an analysis of the original bacterial flora but a periodic examination to determine when the various organisms disappear and when it is safe to subject the wound either to skin graft or secondary closure; for a failure to consider the bacteriological elements in such a problem may result in a failure of the surgical procedure. Such special studies of individual cases as I have described may be called minor research in surgical bacteriology and unless these unusual problems are satisfactorily solved the bacteriological service cannot be called adequate.

Major research. Besides the minor researches which may be required in connection with any individual case there are certain major or perennial problems in bacteriology in which surgeons should be interested. Some of these they very properly share with the internist; for example, pneumonia. Although the pathogenesis of postoperative pneumonia may have a different mechanism from ordinary pneumonia, the bacteriological aspects may very well be the same in both cases. Lung abscess and empyema are of interest both to the medical and surgical services but here it must be admitted that the surgeon is more directly concerned. In like manner both surgeon and internist are involved in bacterial problems associated with the alimentary canal. The internist is most concerned when the disease is due to a disorder caused by the organisms while remaining within the tract, while the surgeon becomes particularly interested when the intestinal organisms invade the tissues outside of the alimentary tract; for example, in peritonitis, cholecystitis, cholangiitis, pylephlebitis, etc. Arthritis may be a problem in which the internist is more concerned but when it becomes a suppurative process the surgeon must take a hand. The surgeon is taking more and more interest in the disease of the peripheral blood vessels, more perhaps from the point of view of the vasomotor nervous mechanism than from the bacteriological point of view but we still have the problems of suppurative phlebitis, postoperative thrombophlebitis with pulmonary embolism, migrating phlebitis, and thrombo-angiitis obliterans which have not yet been satisfactorily studied from a bacteriological viewpoint. Bacteriophage was originally studied intensively in connection with such internal infections as dysentery and cholera but it has been more recently applied to surgical diseases, such as furunculosis, carbunculosis, subcutaneous abscess, and septicæmia. Here is a new attractive and intensely stimulating field in which surgeons with wide clinical experience may profitably expend their powers of observation and experimentation. Septicæmia, in its multitudinous aspects, needs continuous and intensive research before its problems can be solved. Bacteriological problems both medical and surgical very easily lead to more fundamental problems in immunity, both general and local. Indeed the problems of local immunity may be of greater interest to the surgeon than the problems of general immunity because his problems are usually local and his treatment must necessarily be limited to a relatively small region or a single tissue or organ of the body.

From the statements so far made, it is obvious that the problems which face the surgeon from the bacteriological viewpoint are legion. They crowd in upon him from every side and in most clinics and in most hospitals they are either not faced at all or are assigned to those who are not particularly interested or are not qualified to reach a satisfactory solution. If every professor of surgery, or the surgical director of every hospital, were asked if he were satisfied with the bacteriological service which he is receiving, one wonders how many could conscientiously answer "Yes."

THE SOLUTION

If there is to be any solution of this problem it must come not from the bacteriologists, but from the surgeons themselves. It is difficult for a bacteriologist to attack a surgical problem for it is almost impossible for him to acquire a surgical point of view without surgical training. These problems must be attacked by surgeons who have developed the surgical viewpoint, and in the course of their training have acquired the fundamental knowledge of bacteriology. They may then apply it to the surgical problem. Pasteur did not solve the problem of aseptic technique, but Lister, the surgeon, learned the fundamental laws of bacteriology from Pasteur and applied them to a surgical problem. The professor of surgery or the surgical chief cannot go to the professor of bacteriology and say: "Here are our problems of infection, please solve them for us." He must say to his internes and his staff: "Learn the fundamentals of bacteriology and apply them to our problems of infection in surgical conditions." A large part of the time given to train a surgeon must be spent in acquiring the manual dexterity needed to perform operations. Similarly a large proportion of a surgeon's time each day must be given to the actual surgical treatment of his cases. A certain technique is also necessary in bacteriological work but this is more easily acquired and the actual problems are solved more by reading, thinking, observing, correlating, and co-ordinating than by the actual performance of experiments.

However, for the solution of the difficulties arising in any particular hospital only general principles can be laid down. These must be adapted and applied to the peculiar situations which are found in different institutions. The professor of surgery, or the surgical director must make such arrangements as the size and quality of his staff will permit and the results will depend on the amount of time and intelligence applied to his bacteriological problems. It would seem fundamental that the surgical internes should have as part of their regular training at any convenient period in their rotary service the responsibility for doing the routine and emergency bacteriology of the surgical department. They must have supervisory instruction from the staff bacteriologist or from one of the surgical department who has been trained in bacteriology. The former is preferable for the staff bacteriologist is more apt to be able to develop a broader bacteriological viewpoint. Furthermore, at night or on holidays the surgical internes may be required to do the emergency bacteriology for the medical service just as the medical internes may be called upon in emergency to make cultures from surgical specimens. If the surgical internes are required to do the bulk of the routine and emergency bacteriology for the surgical department, the surgical viewpoint will be brought to the study of the specimen. Instead of having the specimen studied in a routine and perhaps abstract way as "pus," it will have a more particular interest in being a special kind of pus from a known location in a particular individual. In such a case the report is much more apt to be of some significance. During this period of bacteriological study and service this work need not be the interne's only duty, but it should be paramount and should be performed as the most important duty of the day. In cases of emergency he must be available to receive and cultivate the material as soon as possible after it is obtained from the patient. No time must be allowed for the material to dry and yield nothing on culture when viable organisms are really present in the material when it is obtained. The period of the interne's service must be long enough for him to learn all of the bacteriological methods, including anaerobic as well as aerobic culture, fermentation and proteolytic reactions, special media and methods for special organisms, animal inoculation, immunological reactions, vaccine and serum preparation, complement fixation and agglutination tests. This training will arouse his interest and give him the groundwork necessary for further studies when he has completed his interneship and has advanced to a higher rank in the staff. If time permits, the interne may assist in the special studies or major research under the direction of one of the older members of the staff, and this will increase his interest in,

and give significance to, his routine and emergency duties.

The special intensive study of a single interesting case can best be carried out by one of the resident or attending members of the staff who is not deluged by routine duties and can have some time to read, study, think, correlate, and apply his knowledge of fundamental bacteriology to the problem in hand. The clinical care of the case need not necessarily be in his hands but there are many things to be said in favor of this arrangement. He is able to apply the treatment indicated without delay, his hands are not tied by a contrary opinion with regard to the treatment. The patient has the advantage of an individual doctor's responsibility for his case. Any change in the patient's condition is noted early and appropriate measures taken to investigate the cause, etc., etc. Such special investigations should be limited to the particular case and enlarged only if they are found to lead to general principles which require the carrying on of research on a larger scale.

The major or perennial problems of surgical bacteriological research should always be under close direction of one of the older men who has had both the clinical and technical experience necessary for its solution or intelligent attack. Such studies must be correlated and carried through in a logical fashion—a part at a time, but with the part seen in its relation to the whole. In these problems the director of research may have technical help but the results obtained by such assistants must invariably be checked by his own observations and he must constantly correlate the various parts of the problem and hold the investigations to the main purpose.

As to the question of how far such researches should go in the direction of pure science, there may be a real difference of opinion. This may depend upon the number of members of the staff available for such work. If there are many, one individual might be assigned to certain abstract phases of the problem but it would seem to be better to leave such aspects of the problem to a regular member of the bacteriology department who might have better qualifications to carry it to a successful solution.

CONCLUSIONS

An adequate bacteriological service for any surgical department directs its attention to routine work, to emergency work, to special research, and to general research. This service can be obtained only when the professor of surgery or the director of the surgical service demands the necessary money and equipment from the authorities and lays out a plan for the training of internes in bacteriological technique, and builds up into his own staff those qualified to carry on minor and major research in the bacteriological problems of surgery.

After many nuclei of such work have been developed in many medical centers friendly rivalry will speed the solution of these problems and it may be possible to correlate or subdivide the problems in some way so that the best service may be obtained with a minimum of wasted time and energy.

TUBERCULOUS TENOSYNOVITIS OF THE HAND

A Study of Thirty-Three Cases of Chronic Tenosynovitis of the Hand[1]

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THE present study of tuberculous tenosynovitis of the hand can lay claim to little of originality. The report of Dr. Kanavel in 1923 has described the condition so well that additions are superfluous and deletion impossible. In the account which follows I have borrowed heavily from Kanavel and am glad to acknowledge the indebtedness.

The material upon which this report is based consists of 32 operated upon cases of chronic tenosynovitis of the hand from the service of Drs. Allen B. Kanavel, Sumner L. Koch, and myself at Wesley Memorial and Passavant Memorial Hospitals, Chicago; they represent a period of observation of over 20 years, the first patient having been operated upon in 1914. Of the 32 cases, 23 are verified tuberculous tenosynovitis, and it is upon these that this paper is essentially based. The 9 remaining of the 32 patients, include 3 instances of multiple tenosynovitis, none of which was definitely proved to be tuberculous, and 6 instances of chronic tenosynovitis clinically indistinguishable from the tuberculous type.

Tuberculosis is the most frequent cause of chronic infection of the tendon sheaths of the hand. Because of the slow development and the not infrequent absence of pain or functional disturbances until late in the course of the disease the tendency for both patient and surgeon is toward delay in seeking or in administering adequate treatment. Frequently the correct diagnosis is not made for many months or even years with consequent loss of valuable time. The presence of a chronic dough-like sausage-shaped swelling over the flexor or extensor tendons is practically always due to tuberculosis, and if rice bodies can be demonstrated the diagnosis is practically certain. Despite the chronicity early recognition of the nature of the disease is necessary if we are to treat it successfully since, if the condition progresses, the tendons themselves are invaded and may be destroyed and fistulæ, secondary infection, and extension to bones and joints are apt to occur. The possibility of a complete cure is attested by the results from our clinic and numerous other surgical clinics.

ETIOLOGY

It is usually stated in the literature that tuberculous tenosynovitis is somewhat more frequent among males than females, according to Zoeppritz in the proportion of males to females of 3:2. Clairmont, Winterstein, and Dimtza of 62 patients found 30 males to 32 females, while our own figures are 9 males to 14 females.

The age incidence shows a predilection for the third and fourth decades, though no age is exempt. Our own figures of 23 cases show a fairly even distribution for the male patients from the second to the sixth decade, while the female patients reveal a very definite preponderance in the third decade.

TABLE A.—AGE INCIDENCE OF TUBERCULOUS TENOSYNOVITIS

Decade	Personal cases* (Kanavel, Koch, and Mason)			Clairmont et al	Total
	Male	Female	Total		
0–10	0	0	0	2	2
11–20	1	3	4	15	19
21–30	3	8	11	13	24
31–40	1	1	2	7	9
41–50	2	0	2	13	15
51–60	2	2	4	7	11
61–70	0	0	0	3	3
71–80	0	0	0	1	1
81–90	0	0	0	1 (82 years)	1
Total	9	14	23	62	85

*In our cases the age is taken as the age of onset and not the age at which patient applied for treatment.

The youngest patient upon whom we have operated for this condition was 19 years of age and the symptoms had been present some 6 months at the time. However, another

[1]From the Department of Surgery, Northwestern University Medical School and Passavant Memorial Hospital.

patient who came for treatment at the age of 23 gave a history of swelling of the wrist and fingers of 10 years' duration which indicates an age of onset of 13 and would make her therefore the youngest in our series. The oldest patient was a female of 60 whose disease began 18 months before operation, i.e., at about the age of 58. Clairmont, Winterstein, and Dimtza report 2 cases in the first decade and 1 in the ninth decade (82 years). The average age of onset in our patients is 32.6 years, with the average for the male patients of 37.9 years and for the female patients of 29.1 years. We can suggest no explanation for this difference in age distribution.

The disease shows a rather definite predilection for the right hand (16 right and 7 left) and for the volar surface (18 volar, 4 dorsal, 1 both volar and dorsal). In the 14 cases reported by Dr. Kanavel in 1923 the right hand was involved in 13 and the left in 1, the latter in a left handed individual. We do not know, however, that the 13 others were right handed, and we do not know how many of the present series are right handed, though the preponderance of involvement of the right hand may be of some significance.

What rôle occupation plays is uncertain. It is usually stated that those who use their hands for manual labor are most frequently victims of tuberculous tenosynovitis. The occupation of housewife occurs in 8 of the 14 females, while the 6 others are nurse, saxophone player, laundress, clerk, beauty parlor operator, and club executive, respectively. Of the 9 males, 2 were clerks, 1 was a clergyman, 1 a banker, and 1 a nightwatchman. The 4 others used their hands for hard manual labor: shoemaker, farmer, mechanic, and coal miner. Hence, although it is usually conceded that manual labor predisposes to the infection, other factors are undoubtedly of equal importance.

Whether the rate of intimate exposure to tuberculosis is higher among these patients than among any other group of patients we cannot say. Of 23 patients, 5 (1 male and 4 females) gave a definite history of tuberculous contacts, i.e., with members in the immediate family with active (usually fatal) tuberculosis. Eleven patients denied any exposure among the immediate family, while in 7 information is lacking. Of the 5 patients with history of exposure 2 subsequently succumbed to tuberculosis.

In 6 instances evidence of other possible tuberculous lesions elsewhere on the body was present. In 1 patient there was an active pulmonary tuberculosis which eventually proved fatal. Another succumbed to a laryngeal tuberculosis. In 1 case a small skin nodule which proved to be tuberculous was excised from the forearm, and in this patient some diminished resonance and fine crepitant râles in the right apex were suggestive, but never conclusive of pulmonary pathology. In another case cervical lymph glands broke down and drained for 5 months after excision of the tuberculous tenosynovitis. In the 2 others tuberculosis was not proved, and the evidence therefore was scanty. In 1 instance there was a history of loss of weight and a pleurisy, while physical examination revealed some suggestive findings in the right pulmonary apex, consisting of some impaired resonance, slightly increased vocal and tactile fremitus, and prolonged expiratory sound. There was some slight cervical adenitis. The X-ray examination of the chest showed some peribronchial thickening, but no apical involvement. In another patient there was a history of pleurisy without effusion which lasted for 3 weeks some 10 months previous to the onset of the tenosynovitis. There were, however, no abnormal findings in the lungs.

The question of trauma is an interesting one. Although 11 of the 23 patients gave a history of trauma, an analysis of these cases leads one to doubt trauma as an etiological factor in all but 3 while in the others the connection between trauma and tenosynovitis is too indefinite, the period elapsing between injury and tenosynovitis is too short, or the history is of an open injury and the source for an inoculation infection is not clear.

In 1 case the patient was cranking a car when the crank came loose and the patient fell on his outstretched right hand and wrist. Immediately after this accident he experienced considerable pain and swelling over the dorsum of the fourth and fifth metacarpals which

lasted several days and subsided completely. About 8 months later a swelling appeared on the dorsum of the wrist which gradually increased in size to that of an egg. There was no spontaneous pain when the tumor appeared and there had been no pain except on use of the wrist. An X-ray examination made at the time the patient came for treatment showed involvement of the radius. A typical dorsal tuberculous tenosynovitis was found at operation and proved to be so microscopically.

The second patient in whom trauma might be a definite factor, also with positive histological proof of tuberculosis, suffered a sprain of the wrist about 1 year previous to the onset of the tenosynovitis. This was also a dorsal tuberculosis, and the first symptom was swelling. Pain here was not spontaneous nor was it present on use of the wrist.

In a third patient trauma must also be considered of possible etiological importance. The patient stated that she had pounded with the palm of her hand upon an ice pick following which there was considerable swelling of the fingers. Several months later a puffy swelling appeared in the palm and later above the wrist, associated at times with considerable pain. Symptoms and findings persisted despite various sorts of conservative treatment for 8 years. At operation there was found a typical gross and microscopic tuberculous tenosynovitis of the flexor pollicis longus sheath and common flexor sheath at the wrist.

In 3 other instances although a trauma

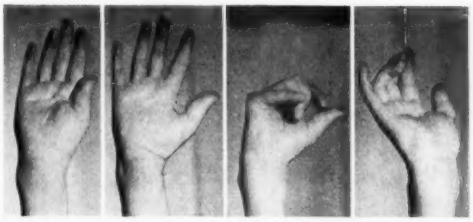
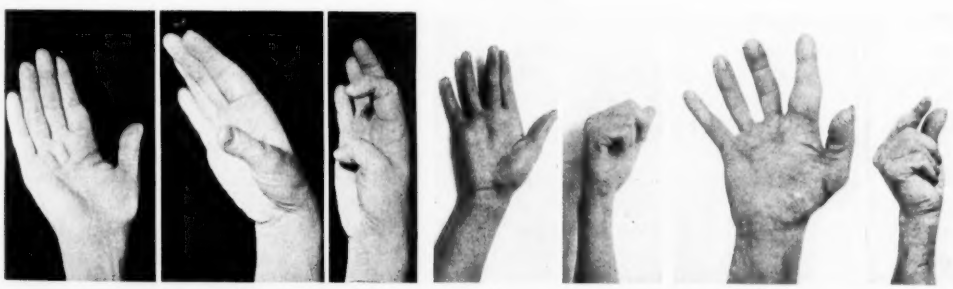


Fig. 1. Tuberculous tenosynovitis of radial and ulnar bursæ with extension into the digital prolongations of the thumb and little finger, involvement of the digital sheath of the index finger, complete destruction of both flexor tendons to the little finger, and invasion of the flexor tendons to the index finger and thumb.

preceded the onset of the tenosynovitis the sequence of events was too rapid to admit any causal relationship. Thus in one instance a severe sprain of the wrist in a mechanic was followed at once by a tuberculous tenosynovitis of the dorsum of the hand. In a second patient a rock fell upon the wrist, and this was followed almost at once by an extensive tuberculous tenosynovitis of the volar sheaths. In a third a mild trauma to the dorsum of the hand was followed in 24 hours by a tuberculosis of the radial and ulnar bursæ and the sheath of the index finger. In 2 others the trauma, if such there were, was so slight as to be only imperfectly remembered by the patient. In this connection, however, it is interesting to note that none of 6 patients with chronic tenosynovitis, in which the microscopic sections failed to bear out the clinical diagnosis of tuberculosis, gave a history of trauma.



a. b. c. d. e. f. g.

Fig. 2. a, b, c, Tuberculous tenosynovitis of digital sheath of right index finger. d, e, Tuberculous tenosynovitis of digital sheath of right middle finger. f, g, Tuberculous tenosynovitis of digital sheath of index finger. The patient had been operated upon 6 years previously for tuberculosis of radial and ulnar bursæ, which were excised and there was no recurrence. The index sheath involvement eventually invaded bone, necessitating amputation of finger.

Fig. 3. Tuberculous tenosynovitis of dorsum of right wrist. Pulmonary tuberculosis present. The typical spindle shaped swelling is well shown.

That tuberculosis of the tendon sheaths may follow direct inoculation of tuberculous material into the sheath is adequately attested by numerous case reports in the literature. In most cases the patients are either butchers who have slaughtered tuberculous cattle (von Tempsky) and inoculated themselves accidentally with a knife or they are attendants in tuberculous sanitaria who injure themselves on broken glass sputum dishes (Muehsam). In only one of our cases was there any suggestion of inoculation. The patient first noted a soreness on the volar surface of the distal phalanx of the right thumb. This was soon followed by the development of a small nodule, at which the patient picked with his pocket knife and from which pus was obtained. This infection was incised and drained, discharge continued intermittently for about a year, at the end of which time the wrist became swollen. Two other patients cited cutting injuries preceding the development of the tenosynovitis. However, the chain of events is not sufficiently clear to warrant a suggestion of inoculation. There was no history of handling of tuberculous material and the

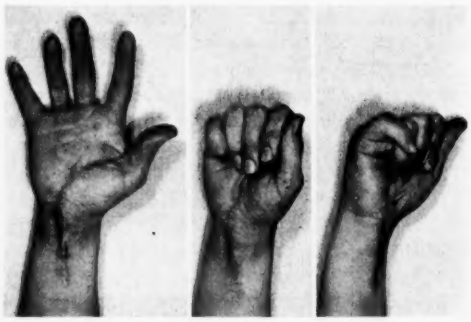


Fig. 4. Tuberculous tenosynovitis of the radial and ulnar bursæ. The radial bursa has been removed, but recurrence has taken place in the ulnar bursa. The typical swelling is shown at the wrist and in the little finger.

patients themselves had no other tuberculous lesions.

In two instances the onset of the tenosynovitis was preceded by an acute infectious disease, in fact in each instance by two acute infectious diseases. In one case there was a severe "flu" of 3 weeks' duration, during the 1918 epidemic. After the subsidence of the "flu" an acute polyarticular arthritis (diagnosed as acute rheumatism) developed, and during this time pain and swelling occurred on the dorsum of the hand. In the other case the patient at the age of 13 contracted measles followed by pneumonia which kept her in bed for 3 months. During the time she was bedridden tenosynovitis developed and persisted for some 10 years when she came to us for treatment. At this time there was no evidence on physical examination of any pulmonary lesion.

In our experience tuberculous tenosynovitis secondary to a tuberculosis of the bones of the wrist is quite rare. In but 2 of the 23 cases did it appear possible. In 1 case the radius and in the other the ulna and triquetrum were the site of the infection and in each case the tenosynovitis was the more severe condition. We have not taken roentgenograms routinely of the hands of patients with tuberculous tenosynovitis and we do not know in just how many cases a bone lesion might have been demonstrated. However, in view of the subsequent histories of our patients, we do not believe the percentage would be large.

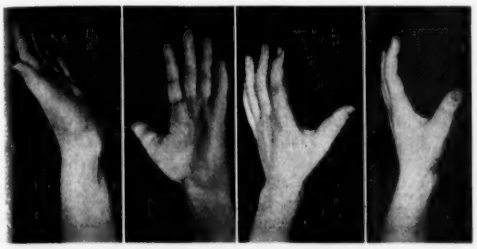


Fig. 5. Tuberculous tenosynovitis of entire radial bursa and of ulnar bursa above transverse carpal ligament. The photographs illustrate the swelling which was present above the transverse carpal ligament at the wrist and over the volar surface of the thumb.

Fig. 6. Chronic non-specific tenosynovitis of radial and ulnar bursæ of both hands.

DISTRIBUTION AS TO SHEATHS

In the majority of instances tuberculous tenosynovitis of the hand involves the volar tendon sheaths (Fig. 1). Of the 23 cases, in 19 or slightly over 80 per cent the volar sheaths were involved, in 1 of these with subsequent involvement of the dorsal sheaths. In 17 of these 19 instances the radial and ulnar bursæ were involved, while in 2 cases digital sheaths were affected alone; in 1 case (Fig. 2, a, b, and c) the sheath of the index finger, and in the other of the middle finger (Fig. 2, d and e). Of the 17 in which the radial and ulnar bursæ were involved together there was infection of separate finger sheaths in 4; in 3 the sheath of the index (Fig. 2, f and g) and in 1 the sheath of the ring finger. In 3 instances this associated involvement was concurrent with the radial and ulnar bursa infection, while in 1 case (Fig. 2, f and g) the index sheath did not show any evidence of infection until some 6 years after successful operative excision of the radial and ulnar bursæ. It is doubtful in this case if the index finger sheath was already infected at the time of the first operation. In 2 of the 3 other cases the digital sheath was excised at the same time as the radial and ulnar bursæ because objective evidence of infection was present. In the other case the patient returned 3 months after operation with recurrence in the ring finger. The sheath we assume was already infected at the time of the first operation, but without clinical evidence thereof.

In 5 cases the dorsal sheaths (Fig. 3) were infected; 4 times alone, and in 1 instance with associated disease in the volar sheaths and carpus. Although isolated involvement of the various dorsal synovial sheaths may occur we have always found multiple involvement. The extensor digitorum communis and extensor pollicis longus sheaths are invariably affected while the other sheaths may escape.

The extent to which the radial and ulnar bursæ may be involved varies somewhat from case to case, while involvement of the finger sheaths or of the dorsal sheaths practically always extends throughout the entire sheath. Thus the radial and ulnar bursæ may be markedly involved at the wrist and the process may extend distally into the distal ends of the two bursæ (Figs. 4 and 5). The disease process may stop in the palm and not invade the thumb or little finger at all or one may be invaded throughout its entire extent while the digital extension of the other bursa may be entirely free. The digital prolongation into the little finger most often escapes. Thus of the 17 cases, in only 5 did the radial bursal prolongation in the thumb remain free of disease, while in only 5 was the digital prolongation in the little finger involved. In no case was the radial or ulnar bursa involved alone. In 1 instance in which the ulnar bursa, from gross inspection at time of operation, seemed free of disease, the radial bursa alone was removed. There was prompt recurrence of the trouble, this time with extensive invasion of the ulnar bursa. This observation coincides with our experience with acute purulent tenosynovitis—that infection of one bursa is in practically every instance followed by invasion of the other.

Although instances of multiple tuberculous tenosynovitis have been reported, it has not

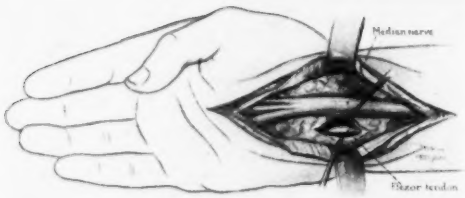


Fig. 7. The median nerve, especially within the narrow confines of the carpal tunnel, is compressed by the swollen sheath beneath it, it may be surrounded by tuberculous tissue, its surface injected and fibers separated by œdematous swelling. Actual invasion and destruction have not been seen.

been our privilege to see any such case. Three cases of multiple tendon sheath involvement have been operated upon, but in none has a tuberculous origin been proved. In each case both hands were involved—in one both the volar and dorsal sheaths, in 1 case the volar sheaths of the right hand, the dorsal sheaths of the left and the left knee joint were affected while in the third the volar sheaths of each hand (Fig. 6). In the 2 first instances the sheaths contained a thin straw colored fluid and a small amount of viscid gelatinous material adherent to the tendons and to the walls of the sheaths. In neither case was there any invasion or destruction of the tendons. In the third case the gross pathological picture was that of a tuberculous process and there was invasion and partial destruction of tendon tissue.

PATHOLOGY

It is customary to divide the tuberculous infections of tendon sheaths into four types: (a) serous, which is very rare, (b) serofibrinous or rice body hygroma, (c) fungus, and (d) cold abscess (Kaufmann, Lexer, Mueller). This subdivision is of no particular practical value except that there seems to be a less severe involvement and less likelihood of tendon destruction in the pure hygroma or rice body type than in the fungus. Since, however, one type tends to pass over by insensible gradations into another and all pathological types may be present in one and the same case the distinction cannot always be made.

GROSS PATHOLOGY

The gross pathological picture presented by tuberculous tenosynovitis varies somewhat depending upon the type or predominating type of lesion and upon the duration of the disease. Thus in very early stages the sheath may be but slightly thickened and the synovial fluid straw-colored and increased in amount while in later stages these pathological changes may progress to produce marked thickening of the sheath with granulation tissue proliferation, caseation, rice body formation, tendon invasion and destruction with secondary infection and sinus formation.

It must be constantly kept in mind that the infection involves both the parietal and visceral layers of the sheaths, and that whatever might be the contents of the sac the primary pathological focus is in the synovial wall.

The description of the gross pathological picture as given by Dr. Kanavel in 1923 cannot be improved upon:

> The affected area, whether it involves the dorsal or volar surface of the forearm, the wrist, the palmar surface of the hand, or the individual fingers appears as a more or less spindle shaped swelling (Figs. 1, e, 3). The swelling may give a definite sense of fluctuation, it may be doughy, it is rarely hard and firm. Early in the course of the disease it may be so ill-defined as to leave a question as to its actual presence. . . .
>
> On incising the skin over the affected area, the deep fascia appears more tense than normal, and the fascia and superficial tissues may appear slightly œdematous. On incising the deep fascia, evidence of pathological change immediately appears (Fig. 7). The tendon sheaths are no longer white, and glistening, but yellowish-white, grayish-red, gray, purple, or bluish-purple.

They appear as definite separate demarcated cyst-like structures, easily separable, in the early stages at least, from the surrounding structures. Occasionally large veins course over the mass and with the purple coloration, which is often present, suggest an angioma. At times in the early cases of hygroma, areas of the sheath may be thin and transparent so that rice bodies if present may be seen through it.

> Instead of herniating quickly through the smallest opening in the deep fascia, the œdematous tissue tends to herniate into the wound only when an incision of some length is made. On incising it, this œdematous tissue is found to consist of the thickened tendon sheaths and tendons, more or less closely matted together (Fig. 7). If the process is not far advanced it is possible to separate the individual

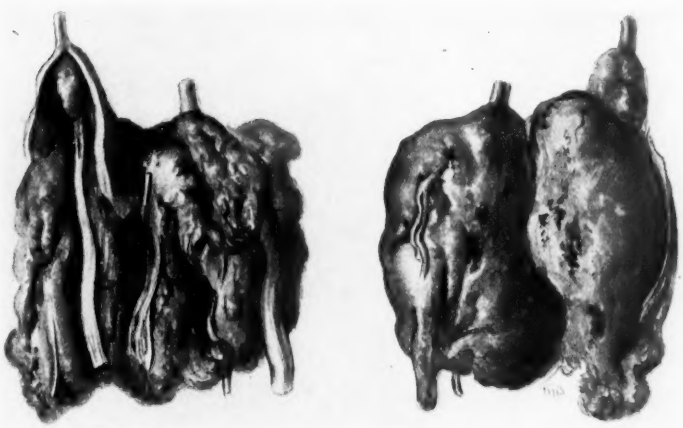


Fig. 8. Drawing of tissues operatively removed, consisting of the radial and ulnar bursæ and frayed invaded flexor tendons to the index and little fingers. The bursæ have been converted into thick walled sacs containing many loculi filled with soft, gelatinous, grayish material. The tendons to the index and little fingers within the sac were transformed into a yellow caseous mass.

tendons from one another. Then it may be seen that the involved tendons, with their sheaths, form a fusiform enlargement. The vascular sheath varies in thickness from 0.5 to 3 millimeters, depending on the duration of the disease. On incising the sheath the thickened tendon appears within it. Much of the fusiform enlargement disappears as thin, straw-colored fluid occasionally with flakes of fibrin pours from the open sheath. The thickened tendon is still free in the sheath, and on incising the tendon, it is found that the thickening is due to involvement of the visceral layer of its sheath. The white fibrous tendon is still intact within the soft, vascular granulation tissue which has replaced the normal tissue paper visceral layer of the tendon sheath. During this stage the tendon can still be dissected out of the tuberculous sheath and shows little or no pathological change. This is the earliest stage of the so-called hygromatous form.

In a later stage the sheath becomes partially obliterated by fibrous tissue formation. Fluid is confined to a definite portion of the sheath, and rice bodies may appear in the fluid.

At times there is found a formless pultaceous or fibrinous material in the sheath of the same color as rice bodies and thought to be an early stage in rice body formation. We are fre-

Fig. 9. Tuberculous tenosynovitis of the radial and ulnar bursæ. Process in palm has spread beyond anatomical limits of the sheaths involving middle palmar space.

Fig. 10. Tuberculous tenosynovitis of the radial and ulnar bursæ accompanied by an invasion of the thenar space.

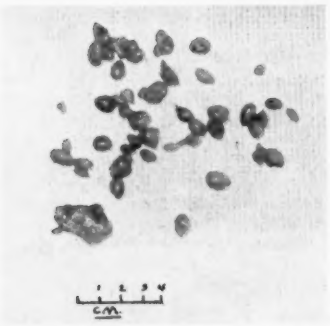


Fig. 11. Rice bodies removed in a case of tuberculous tenosynovitis. The variable size of the rice bodies is shown, the largest one is over 25 millimeters in length, the smallest less than 2 to 3 millimeters.

quently surprised at the scanty amount of fluid if there are numerous rice bodies present.

Still later the fluid is replaced by a caseous substance which may be localized in one or two areas. The tendon sheath is replaced by granulation tissue, and later by fibrous tissue; fragmentation of the tendons takes place (Figs. 8 and 28), and several tendons, or all of them, may be firmly bound together in a mass of fibrous tissue. . . .

These varying conditions, described as characteristic of different stages of the disease, may at times be seen in the same individual. Straw-colored fluid with rice bodies may be present in the radial and ulnar bursæ while the tendons of the fifth finger in the palm have undergone almost complete fragmentation and division. Such fragmentation can occur while the tendon still moves freely in its sheath. . . .

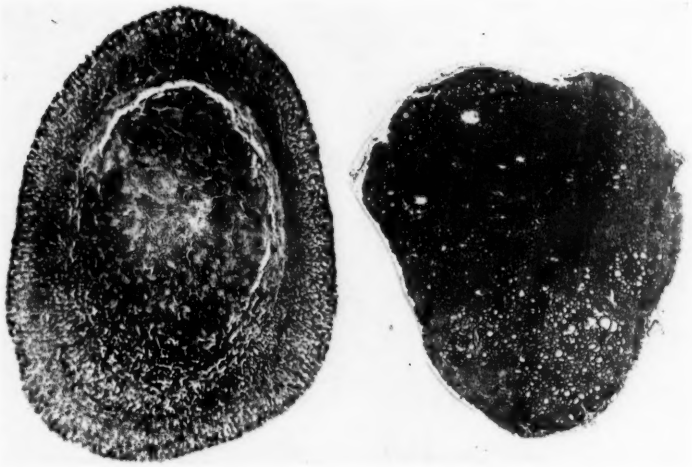
The final stage of the uncomplicated disease, the fungus form, is characterized by extensive formation of granulation tissue and caseation, with or without rice bodies. The exposed tuberculous mass is very vascular, soft, and of a grayish-red or purple color. It looks like a sausage-shaped enlargement which has replaced the tendinous mass. When the soft, thick granulation tissue forming its outer wall is incised, the interior of the tendon sheath with the involved tendon is exposed. There may be some thick, gelatinous, straw-colored fluid present; there may be rice bodies; there may be only caseous material within the synovial space. At times the swelling may be bilocular, with rice bodies present in one loculus and gelatinous fluid in another. The lining membrane of the tendon sheath is no longer glossy and shining, but dull and lusterless. It may be adherent to the tendon in a part of its course; it frequently shows areas of caseation and necrosis.

Occasionally the infected sheath ruptures and one or more of the fascial spaces of the hand and forearm are invaded. The middle palmar space or the thenar space may be distended and filled with tuberculous tissue (Figs. 9 and 10). However, it is somewhat more usual for extension to occur into the forearm. These extensions when they occur in the palm tend to be encapsulated though this is not the case in the forearm.

"The visceral layer of the sheath is involved like the parietal layer." The tendons lose their white shiny luster, their surfaces are covered by the same type of tissue as lines the interior of the sheath (Figs. 8 and 28). When this is removed the tendons may appear normal or there may be invasion of the tendon substance by the tuberculous tissue. In the early stages this is evidenced by a separation of the fibers by a small red or reddish-brown mass of tuberculous granulation tissue. Later the tendon appears soft and swollen, greyish-yellow, or even caseous and frayed. With this invasion and destruction the tendon soon loses its tensile strength and ruptures. Once the tendon has become invaded the tuberculous process tends to spread for a short distance in a longitudinal direction so that a section made across normal appearing tendon distal or proximal to the area of definite tuberculous invasion may show a central area of destruction (Fig. 14, b).

This process of tendon destruction is most marked in places where the tendon is confined within a narrow space, that is, within the carpal tunnel under the transverse carpal ligament. This is probably due to the swelling which interferes with the blood supply of the tendon and makes it more easily invaded by the infection.

In 12 of our 23 patients one or more tendons were either completely destroyed or so badly involved that whole segments required removal and plastic repair was necessary in 10 of these, while in another 5 patients there was considerable fragmentation and invasion, but it was possible to excise the affected portions without sacrificing the whole tendon. This is a rather startling figure and again emphasizes the fact that both visceral and parietal sheaths are attacked in the disease. There is a certain correlation between severe tendon involvement and duration of the condition before operation. The duration of symptoms previous to treatment



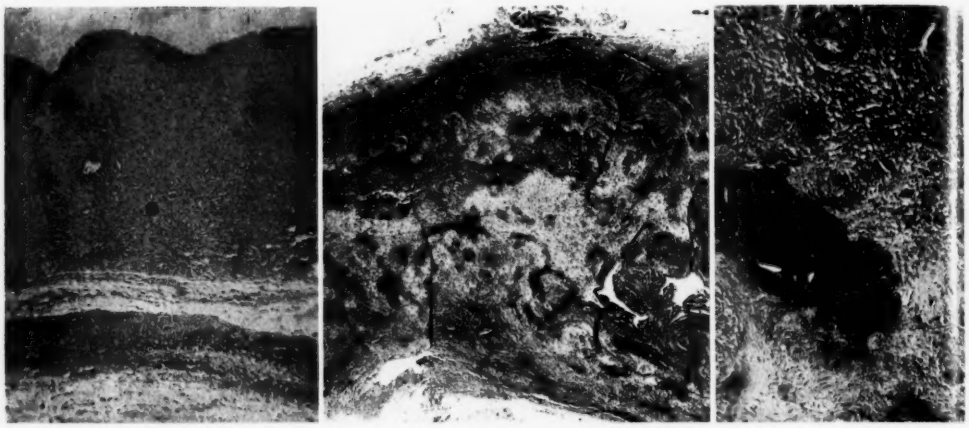
a. b.

Fig. 12. a, Photomicrograph of rice body (× 35). This is the type made up of amorphous fibrils and coarse granules of fibrin-like substance laid down in a concentrically laminated fashion. b, Photomicrograph of cellular type of rice body composed of round or polygonal cells with many large spaces filled with homogeneous material (× 35).

in 12 patients with marked tendon destruction requiring excision of whole segments of tendons averaged 51 months. In 5 patients with marked involvement, but not sufficiently severe to necessitate more than excision of superficial layers from the tendon, the duration averaged 33.2 months, while in 6 patients with slight or no tendon invasion the average duration was 23 months. This correlation holds in general even though the severity of the process shows marked variation from case to case. Thus although in 2 patients with marked destruction the condition had been present for 10 years, the duration in the other patients in this group (ranging from 6 months to 5 years) averaged 31.1 months. In the group with the least involvement there was 1 patient in whom the swelling had been present for 8 years, in the 5 remaining patients, however, the duration ranged from 5 months to 2 years with an average duration of 12 months. We can say, therefore, that, in general, if the disease has been present over a year tendon invasion is sure to be found, and that if it has been present for 3 years or longer there will be considerable destruction and that plastic repair will be needed.

The tendons most frequently severely invaded and destroyed are the flexor tendons of the little finger; next are those of the index finger, and then those of the middle and ring fingers. The flexor pollicis longus is somewhat more frequently involved than the flexor tendons to the index finger, but this involvement is seldom so severe and in our experience has never destroyed this tendon, and plastic repair has never been required. On the dorsum of the hand the extensors of the thumb, especially the extensor pollicis longus, are frequently fragmented, while the common extensors though often fragmented are seldom actually destroyed.

In 9 instances other structures in the hand besides tendon sheaths and tendons were invaded. In only 3 instances were bone and joint changes found, and in each case we felt that this was distinctly secondary to the tenosynovitis and not the primary focus. In 1 of these the bones and joints of the index finger were so extensively invaded that amputation of the finger was necessary. In another case there was a focus in the lower end of the radius which was not curetted and which healed completely following excision of the infected



a. b. c.

Fig. 13. a, Synovial membrane in tuberculous tenosynovitis. The sheath is converted into tuberculous granulation tissue in which tubercles are often though not always found. b, Tuberculous sheath. Structure of the sheath almost entirely replaced by massive infiltration and caseation. c, Tuberculous giant cells and caseation.

sheaths and immobilization. In a third case the lower end of the ulna and triquetrum were destroyed by disease and were removed operatively. In 6 cases there was invasion of muscles, once in the forearm with a marked tuberculous myositis, and 5 times in the hand, 3 times of a lumbrical muscle alone, and twice of the adductor pollicis (in 1 of these in association with lumbrical tendon invasion). In 1 patient there was a tuberculous focus on the skin of the forearm near the elbow. In 4 cases sinuses had formed, in 3 instances they were draining at the time of the operation and in 2 instances led to some postoperative reaction, in neither, however, very severe.

The median nerve because of its location directly on top of the ulnar bursa and its presence within the narrow confines of the carpal tunnel along with the flexor tendons is always more or less involved in tenosynovitis of the volar surface of the wrist (Figs. 7 and 27). It is often flattened out on the surface of the infected bursa and may be quite swollen and enlarged, but we have never seen it invaded even in the far advanced cases with tendon and bone destruction. The ulnar nerve lies in a more protected location and we have never seen it involved in any manner. The digital nerves, in cases of tenosynovitis of the digital sheaths may be embedded in the tuberculous mass and considerable care may be required to dissect them free.

RICE BODIES

The contents of the sheath which have attracted the most attention and considerable discussion are the rice bodies. These are small ovoid, triangular, or kidney shaped masses flattened or facetted with smooth shiny polished external surfaces resembling grains of rice (Fig. 11). They vary in size from millet seeds or tomato seeds up to the size of small kidney beans. There may be only a few in the sheath, occasionally only one, or there may be literally hundreds of them. They are most striking in appearance. At times large cake-like masses of the same appearance as the rice bodies are found or the sheaths may be filled with a soft amorphous uniform appearing grey material which looks like the same substance which makes up the rice bodies. Not infrequently the bodies are found to hang by slender stalks from the wall of the sheath.

The method of formation of the rice bodies is still the subject of considerable controversy. It has been shown that they may occur in conditions other than tuberculosis, e.g., arthritis, syringomyelia, chronic non-specific bursitis, but their presence within a tendon sheath practically always speaks for tuberculosis.

The histological picture of a rice body presents chiefly granular and poorly defined concentrically lamellated masses of coarse, granular, and thread-like fibrinous material (Fig. 12) or tissue which has undergone coagulation necrosis which contains here and there a giant cell and occasionally the tubercle bacillus. In some instances the rice bodies are very nuclear, composed of round or polygonal cells with many large spaces filled with homogeneous material. Tubercle bacilli may frequently be demonstrated in them. Goldmann and Garré showed that these bacilli are capable of producing tuberculosis in a guinea-pig, if the rice bodies are implanted in the peritoneal cavity, provided a sufficient number are implanted.

MICROSCOPIC PATHOLOGY

The histology of tuberculous tenosynovitis is similar to that of tuberculosis of the synovial membrane of the joints. The sheath is thicker than normal (Fig. 13) and in the outer part there is usually a considerable increase in fibrous tissue with increased vascularity. The vessels of this fibrous layer may show perivascular round cell infiltration or a tuberculous endarteritis. Lymphocytes in considerable abundance are frequently found throughout the fibrous layer. Closer in toward the inner surface of the sheath may be found numerous or scanty histological and conglomerate tubercles contained in dense chronically inflamed fibrous tissue. The surface of the sheath is usually converted into vascular granulation tissue, which resembles ordinary granulation tissue except for the fact that it frequently contains tubercles. Fibrin deposits may be found on the surface of the synovial membrane or large and small blunt papillæ may be given off. These papillæ may be cellular and vascular or they may be necrotic.

In the more advanced or in the more rapidly developing cases larger or smaller areas of caseation may occur (Fig. 13) and typical tuberculous ulceration may be present on the surface of the synovial membrane.

Similar changes occur in the visceral portions of the sheath which in advanced cases may be converted into ragged and irregular necrotic and granular masses adherent to the surface of the tendon. The fibrils are separated by granulations and the tendon may become converted into a mass of conglomerate tubercles (Fig. 14). Once inside the tendon the process may infiltrate proximally and distally from the site of involvement, leaving the outer zone of normal tendon surrounding a central necrotic area.

It is of interest to note that the pathological picture may not always show tubercles so that a diagnosis of tuberculosis may not be made by the pathologist unless the source and clinical history of the material is known. The tuberculous infection may produce only a chronic inflammation which could be due to any other infectious agent. In such cases a guinea-pig test is necessary to make the diagnosis.

SYMPTOMS AND CLINICAL COURSE

Tuberculous tenosynovitis is characterized by the insidious development of a slowly progressive, painless or painful, swelling over the anatomical area of the tendon sheath or sheaths involved. As the disease develops various symptoms occur, some due to the extension of the swelling, some to pain, and some to destruction of tendons. If long neglected, secondary involvement of adjacent structures especially bones and joints, and fistulæ with secondary infection, occur.

The *initial symptoms* of tuberculous tenosynovitis are usually pain and swelling or simply swelling over the involved sheaths. In fully one-third of the cases, however, sensory or functional symptoms precede the development of the swelling. Thus in one case there was first noted a stiffness in the distal interphalangeal joint of the ring finger, followed in several months by similar stiffness in the index and little fingers and not until 5 months later did swelling begin at the wrist. In another case the same peculiar stiffness was first noted in the little finger on awakening in the morning; this was soon followed by stiffness in the other fingers, while swelling did not appear for a year. In a third case stiffness followed an injury and was rather early associated with slight swelling which did not become marked for nearly 3 years.

In another type of case pain or tingling is the first symptom. In one such case a soreness was noted on the volar surface of the distal phalanx of the thumb, this was followed by the development of a small nodule which was picked off and allowed the escape of pus. Following this the thumb became swollen. In 2 cases pain was present for 2 and 3 years, respectively, before swelling of any noticeable degree was present. In another case, the pain, spontaneous as well as on use, started in the proximal interphalangeal joint of the middle finger, and only sometime later did swelling make its appearance. In still another instance the initial symptom was a numbness, tingling, or needle-like pricking sensation in the middle finger. This tingling progressively involved the other fingers and only after some time had elapsed did swelling occur at the wrist. The leathery crepitus which is so typical of traumatic tenosynovitis may occasionally appear at the onset. However, we have never noticed it in any of our patients. This leathery crepitus must not be confused with the grating or shot-like crepitus which appears late in the disease which is due to the presence of rice bodies.

The *swelling* may appear as a sudden œdema of the hand which very often quickly subsides under rest and heat, only to recur at some later time and to be gradually replaced by the more tense permanent swelling over the anatomical areas of sheaths involved. The swelling most often makes its appearance at the wrist and as it enlarges proceeds distally into the palm, and later into the digital sheaths of the thumb and little fingers. If the digital sheath of the index, middle, or ring finger is affected, the swelling first appears over the proximal phalanx and later, as the cul-de-sac becomes distended, progresses proximally into the palm over the metacarpophalangeal joint. In cases of long standing the process extends beyond the border of the sheaths and becomes manifest as globular swellings in the various fascial spaces of the hand or forearm. The thenar space and the subfascial spaces over the thenar area may be distended so that a picture resembling thenar space abscess is produced (Fig. 10). In the same manner the middle palmar space may be invaded and a tense globular swelling may project from the palm of the hand (Fig. 9). More often the fascial spaces in the forearm are invaded, thus producing swelling above the wrist well beyond the outlines of the proximal ends of the radial or ulnar bursæ.

The *pain* in tuberculous tenosynovitis while present to some degree in all but a few patients is seldom severe. When it is severe it is described as a burning or throbbing ache, often radiating upward over the forearm, made worse on use of the hand. In such cases the pain is worse at night and the patient is often awakened by it at two or three o'clock in the morning. The pain may respond at these times to the application of heat or cold. For some reason or other the pain does not tend to persist as a prominent symptom throughout the course of the disease. It may become more and more severe during a period of 1 to 2 years and then subside or even entirely disappear. The fact that a similar subsidence of pain may follow incomplete operations or even aspiration suggests that this peculiarity is due to tension within the bursa which is relieved either by rupture of the bursa or by mechanical drainage.

Another characteristic of the sensory disturbance is its frequent reference either as actual pain or as burning, tingling, or numbness over the peripheral distribution of the median and less often ulnar nerves. Such reference is to be explained by the almost constant involvement of the median nerve and less frequent of the ulnar nerve in the pathological process. The radiating pains may pass down into the fingers, or upward over the forearm to the elbow. These also may gradually subside as the disease progresses, a fact which is somewhat difficult to explain when at operation we find the nerve swollen and engorged.

As the disease progresses various *functional disturbances* make their appearance. These may vary from slight or no disability in the early case to actual loss of various movements due to tendon destruction or to the interference with motion by the actual size of the swelling which may prevent complete closure of the fingers, adduction of the thumb, or flexion and extension of the wrist. Pain on

motion may lead to limitation of use. In a few instances the patient recognizes the actual time at which a tendon has divided and may remark that he felt something snap and that afterward a certain movement was absent. A complaint which patients frequently make is the inability to make a fist or completely close or extend the fingers. This may be the earliest functional disturbance and one which frequently persists for months after removal of the infected sheath.

EXAMINATION

Examination of the hand shows a swelling or enlargement over the course of the involved sheaths (Figs. 1, 2, 3, 4, 5). In the case of the volar sheaths there is frequently a fusiform or spindle shaped swelling of the wrist which is divided into two fairly distinct portions, a proximal and a distal, by the transverse carpal ligament. This constriction may be visible and is practically always palpable. The communication of the two loculi can be made out by pressure on one and palpation of the other when the tension will be found to increase as presure is exerted. The palmar swelling may be more marked than that in the forearm (Fig. 9) and may occupy the center of the palm and show no demonstrable connection with the forearm enlargement. Such a tumor mass, often cystic in its consistency, may indicate middle palmar space invasion. The swelling may appear perfectly regular and smooth in outline, or it may appear irregular and lobulated as if made up of a number of separate masses, or of one mass of varying consistency and composition.

The swelling in the base of the palm, indicative of ulnar bursa infection, may be directly continuous with swelling of the fifth finger (Fig. 4), or as is not infrequently the case there may be no external evidence of involvement of the digital sheath, even though it is found invaded at subsequent operation. Similarly the thumb may be markedly swollen along its volar surface with disease of the radial bursa (Fig. 5).

With tuberculosis of the sheaths of the index, middle, and ring fingers there is produced a sausage-shaped or fusiform enlargement which may lead to confusion with spina ventosa (Fig. 2). However, examination will show the definite localization of the involvement to the volar surface of the finger and the prolongation into the palm to the limits of the sheath.

The dorsal swellings tend to be more irregular and to be made up of several distinct tumors which correspond to the numerous separate sheaths which may be involved here (Fig. 3). Thus several tumors may be felt as elongated masses which cause, as in the case of volar disease, a fusiform swelling of the wrist with a poorly marked constriction at the center. The swellings on the dorsum may produce localized globular masses, often attaining the size of a hen's egg or lemon (Fig. 15). The distal limit of the masses corresponds to the limits of the dorsal sheaths, i.e., about the middle of the metacarpus, while they extend proximally 1 to 2 inches above the dorsal carpal ligament.

The swellings may vary considerably in consistency. Some are hard, firm, and tense, others are soft, boggy, and doughy, while still others are fluctuant or semifluctuant. The consistency may vary considerably within the same tumor, some areas may be quite hard, others soft or fluctuant, or even cystic.

Crepitus or grating is nearly always demonstrable when the rice bodies are present. They give the sensation of shot being moved back and forth in a closed sac. The patient will usually have noted this himself. In the very early stages the leathery crepitus of tenosynovitis may be noted but this is rarely found by the surgeon.

Usually the skin is uninvolved, it may be slightly reddened or if considerable tension, particularly with middle palmar space invasion, it may be white and tense. There is no increase in local heat and no tendency for the skin to become attached to the underlying mass. In the later stages of the disease with cold abscess formation, fistula and secondary infection lead to the typical changes (Fig. 23).

Tenderness is not a marked characteristic though in a few instances we have noted some, and in one, considerable tenderness. While motion of the wrist may cause pain, pressure applied over the mass does not necessarily do so.

PROGNOSIS

No case should be allowed to progress to the stage at which severe secondary infection jeopardizes the patient's life. In a certain number of cases recurrence will take place despite careful operative excision of the diseased sheaths. Some will require several operations, either because of incomplete removal or because of involvement of tissue which at the initial procedure does not seem to be diseased.

Of the 23 cases of histologically proved tuberculous tenosynovitis treated by us 2 have succumbed to tuberculosis. One died of laryngeal tuberculosis 12 years after the initial operation or 14 years after the onset of the tenosynovitis. The other patient had an active pulmonary tuberculosis at the time of operation (under local anæsthesia), went to Colorado immediately afterward for treatment, and succumbed some 6 years after operation and 6½ years after the development of the tenosynovitis. (A third patient succumbed to a "heart attack" 2 months after operation.) So far as we have been able to ascertain the two patients mentioned have been the only ones who have died from tuberculosis.

Most of the patients had had some attempts at treatment before we saw them. This consisted in most cases of the application of a plaster cast or some other type of immobilizing apparatus for a variable period of time, usually on an empiric basis since in very few instances had the correct diagnosis been made. In a few instances hot dressings were applied to control pain, in some various salves and ointments were prescribed for local use, and in others ultraviolet therapy was instituted. In none of these cases was there anything more than temporary alleviation from symptoms and in this connection the following history is of considerable interest.

Mrs. M. B. (P.M.H. No. 12249) entered Passavant Memorial Hospital, November 16, 1932, complaining of stiffness and soreness of the right hand, difficulty in closing the fingers of the hand, swelling above the wrist and in the palm, and a grating sensation upon movement of the fingers. The trouble dated back to February, 1928, about 5 years previously, and was thought by the patient to have followed a slight trauma sustained on the dorsum of the hand while she was cleaning a wash-bowl. The injury was not especially painful but, on the day following, the index and little fingers became stiff and swollen. She consulted a physician who gave the hand a vibratory treatment and asked her to return in 3 days, at which time there was swelling over the knuckles and in the distal portion of the palm. She continued treatments for some 6 months during which time the hand grew steadily worse. Infra-red light, ultraviolet light, X-ray, diathermy, and vibration were all tried and finally the hand was immobilized by bandaging, after which it became very stiff. By the end of the 6 months the swelling had extended into the base of the palm where the patient said she thought she could feel liquid. For the next 6 months she took osteopathic treatments, which she felt made the condition worse, so she consulted another physician who made a diagnosis of traumatic neuritis and later changed it to arthritis. She was given autohæmotherapy twice a week for a considerable period of time, with no results. She then took a course of treatments with another osteopath, and gave up after 4 months with no improvement. Another physician was seen who painted the arm and hand with tincture of iodine and wrapped it with copper wire. This was left on for 2 weeks with no change in the swelling. During the next 2 years she consulted numerous other doctors and osteopaths. X-ray pictures were made and all sorts of treatments attempted. Sometime in the spring of 1931 a grating was felt on flexion of the index and little fingers. Just how this was interpreted we do not know, possibly as a Charcot joint, for about this time she was told the trouble was of nervous nature and was advised to consult a nerve specialist about it. Another physician at this time told her the wrist was fractured and would require fracturing over and resetting. Nothing further was done until the spring of 1932 when the patient in desperation took a course of Vitanoid treatments. These consisted of wrapping a rubber tire about the body five times daily and placing the hand on the tire. She kept this up for 3 weeks without result. In October, 1932, she consulted a doctor who gave her a complete examination and made an X-ray examination of the chest. This physician thought the trouble was tuberculosis and suggested operative treatment. After further consultation an operation was decided upon. At operation an advanced tuberculous tenosynovitis of the radial and ulnar bursæ and the digital sheath of the index finger was found, with many rice bodies, some very large (Fig. 11), and with considerable fragmentation, though not complete destruction of tendons.

In 3 patients the swelling was aspirated elsewhere one or more times, with some relief from the pain, but almost immediate recurrence of the swelling. In one case the aspiration treatment was followed by sinus formation and the discharge of rice bodies from the wound (Fig. 16).

In 7 patients operation had been performed previous to the time we saw them. In 5 of these patients the procedure was fairly extensive and was repeated once in 1 patient and twice in another. In the 2 other patients very minor procedures were attempted, in 1 merely incision, in the other a small bit of tissue was excised.

Of the 23 cases 6 required two or more extensive operations before the process could be eradicated.

1. In 1 case a thorough excision of the radial and ulnar bursæ was followed in 6 years by a tuberculous tenosynovitis of the digital sheath of the index finger. This was excised but recurred again in 4 months with such bone involvement that amputation of the finger was thought advisable. It is doubtful if this sheath was involved at the time of the initial operation.

2. In another case (Rutt) a thorough excision of the radial and ulnar bursæ was followed in 3 months by infection in the digital sheath of the ring finger. This sheath was excised and 2 years later there was no recurrence. In this case the digital sheath was probably already infected at time of the first operation, but was not recognized.

3. J. M. (W. 110195, P.M.H. 880) was operated upon for a tenosynovitis of the right middle finger. This recurred some 5 years later and a second excision was performed.

4. P. (W. 119234, 121125) was operated upon for an extensive tuberculous tenosynovitis of the radial and ulnar bursæ. Four months after the operation he returned with a similar process on the dorsum of the same hand which was also removed. Ten months later a cold abscess over the head of the ulna was opened and curetted.

5. M. (W.M.H. 134939, 137599, P.M.H. 708, Figs. 30 and 31) presents an interesting history in that three attempts were made to treat the patient operatively previous to our operations; and we were required to perform three further operations before the process was completely eradicated. In the first of our operations the common extensor sheaths were excised. Six months later a recurrent infection about the extensors of the thumb was found and removed. Eighteen months after the second operation there was another recurrence about the extensors of the thumb with complete destruction of both the long and short extensors. The long extensor was replaced by a tendon graft. There has been no recurrence of the process 4 years after this last operation.

6. W. (W.M.H. 142434, 144308). In this patient an extensive tuberculosis of the radial and ulnar bursæ and of the common digital sheath of the index finger was excised (Fig. 1). Four months later she returned with a recurrence above the wrist. This was found to have invaded the muscles of the forearm.

Recurrences have occurred in 5 other instances but re-operation was not performed in any. In 1 case an advancing pulmonary infection made operative interference inadvisable. In another a sinus with secondary infection developed. This was treated conservatively with plaster cast and sunlight for 9 months. The process subsided and a re-examination 12 years after operation showed a perfectly functioning hand (Fig. 17). In 3 other cases, recurrences have taken place 3 months, 20 months, and 16 months, respectively, after extensive operation. These patients have been advised to have another operative excision.

That lasting cure may be obtained over a long period of years by proper treatment is attested by a number of our cases of which those illustrated in Figures 16, 17, 18, 19, and 20 are examples.

Of the 23 cases, postoperative information is entirely lacking on 5. Of the 18 remaining, 13, or over 72 per cent, have remained free of recurrence for periods varying from 2 months to 12 years after operation:

M. W.M.H. 89205—*2 months;* S. W.M.H. 113373—*3 months;* G. W.M.H. 130029—*1 year, 7 months;* R. W.M.H. 92841 and 94523—*2 years;* T. P.M.H. 6777—*2 years, 4 months;* S. P.M.H. 6102—*2 years, 6 months;* P. P.M.H. 5781—*2 years, 7 months;* M. W.M.H. 134939, 137599, and P.M.H. 708—*4 years;* O. W.M.H. 46977, 86102, 88771—*6 years;* G. W.M.H. 124880—*7 years;* C. W.M.H. 86002, *7 years, 3 months;* M. W.M.H. 117167—*7 years, 10 months;* S. W.M.H. 94649—*12 years.*

Of the 5 remaining cases, 2 patients have died, one 6 years after operation of pulmonary tuberculosis and with recurrence of the tenosynovitis, the other 2 months after operation of acute cardiac failure. The 3 others have recurrences for which further operative treatment has been advised.

DIAGNOSIS

The differential diagnosis is usually not difficult. *Gonorrhœa* may rarely be confused. This, however, is always metastatic, is preceded by the primary infection (usually urethral) by some 3 weeks to 3 months and the onset is likely to be more acute, though it may rarely resemble tuberculosis. The extensor sheaths are more likely to be involved than

the flexor, the condition is likely to be much more painful than tuberculosis, and is followed more quickly by marked functional loss.

Syphilitic tenosynovitis is very rare, may produce an almost identical clinical picture with tuberculosis, and even on a pathological basis may be almost impossible to differentiate. It is more likely to be bilateral, is practically always painless, and produces no, or few, functional troubles. Two types have been described, an acute or subacute type, occurring during the early secondary stage, and a chronic or gummatous type in the tertiary stage. The acute type is manifested by painful swellings over the tendon sheaths, with some redness of the skin, slight or occasionally marked functional disturbance, and occasionally crepitation. In some cases a luetic hygroma occurs with slight pain and few symptoms of inflammation. The gummatous type has been especially well described by Schuchardt. It is this type which is more likely to be confused with tuberculous tenosynovitis. In Schuchardt's case there were numerous, slowly developing, rounded, and flattish spindle shaped nodules on the dorsum of the hand, which broke down, producing granulating ulcers with overhanging borders through which pus and caseous masses were discharged. The presence of associated luetic findings and of bone and periosteal changes with a positive Wassermann reaction and a response to specific therapy should assist in making the diagnosis.

The common *dorsal ganglion* must occasionally come into consideration. This usually occurs as a tense globoid fluctuant mass over the dorsum of the wrist, most often on the radial side, and seldom is larger than a hazel nut. The surface is smooth, it is not attached to the skin or tendons and produces slight functional disturbance and pain. Early tuberculous tenosynovitis (Fig. 15) may be mistaken for a ganglion and serious mistakes made in the treatment.

Other conditions which may simulate tuberculosis are *xanthoma* of the wrist of which we have seen 2 cases. In 1 the carpal bones were involved, in the other the tendon sheaths. The differential diagnosis is difficult, but since the treatment for the two conditions is the same the difficulty is not without its compensations. The xanthomata tend to be more fibrous and harder than the tuberculous disease and do not produce rice bodies.

Arborescent lipoma of the tendon sheaths is very rare but may produce almost the identical findings as tuberculous tenosynovitis. However, the functional disturbances and pain are less and the tumor grows more slowly. It is said that these fatty tumors become quite hard when exposed to cold (Straus).

Vascular tumors, especially the plexiform types of angiomata, may cause diffuse swellings at the wrist, but the subcutaneous vessels are usually enlarged and the tumor increases in size when the hand is dependent or when the venous return is interfered with.

Carcinoma would rarely lead to confusion except in a late ulcerative stage associated with marked inflammatory swelling when a secondarily infected tuberculous tenosynovitis may rarely be simulated.

Bony and cartilaginous tumors of the hand would seldom lead to confusion and would be definitely diagnosed by the X-ray.

Chronic non-specific tenosynovitis. There are a certain number of cases (6 in this series) of chronic tenosynovitis which behave clinically like tuberculous tenosynovitis, but which cannot be proved to be such. Many of these without careful laboratory study would be diagnosed tuberculosis. It is not improbable that a certain number of cases diagnosed as "rheumatic" tenosynovitis are in reality a specific infection. The 3 following cases are briefly described because they are indistinguishable clinically from the tuberculous type and are illustrative of the 6 personal cases.

G. K., P.M.H. 1647 (January 25, 1930–January 30, 1930). A manufacturer, 50 years of age, entered the hospital because of a swelling on the dorsum of the right hand, first noted one morning on arising, about 3 months previously. There was no history of preceding trauma or infection and the swelling was not associated with any untoward symptoms, nor was movement or function in any way impaired. There was no history of tuberculosis in the family and except for occasional "winter cough" the patient gave no history suggestive of pulmonary tuberculosis. Since, however, there was some impaired resonance of the apices, a roentgen examination was made of the chest which revealed old healed apical infection on both sides.

On the dorsum of the right hand there was seen a flattened egg-sized mass which extended from the dorsal carpal ligament distally to about the middle of the metacarpus and laterally from the second to the fourth metacarpal bones (Fig. 21). In the middle dorsal area of the forearm just above the dorsal carpal ligament was a soft, fluctuant area about 2 centimeters in diameter and raised about one-half centimeter above the skin level. These swellings had remained the same since onset.

At operation January 2, 1930, under local anæsthesia, a middle dorsal incision was made from one-half inch above the metacarpophalangeal joints to 2.5 inches above the wrist exposing the tumor under the subcutaneous tissues and the dorsal carpal ligament. On opening the tumor yellowish, gelatinous fluid poured out, and within the tumor in its most prominent portion was a free, flat, hyaline-like mass, likened to the early stage of rice body formation. The tendons of the extensor digitorum communis ran through the tumor surrounded by the gelatinous tissue and a reddish-purple granulation tissue. The extensor indicis proprius was involved, the extensors of the thumb and the extensors of the wrist were apparantly not involved. The tumor and granulation tissue were carefully excised. The dorsal carpal ligament was also excised where it overlay the tumor mass. A narrow band of ligament was reconstructed with the aid of healthy looking tissue at the radial side. None of the tendons were frayed or fragmented though the diseased tissue was intimately attached in places to the substance of the tendons. The pathological report on the tissue removed stated: "the lining of the tendon sheath is composed of granulation tissue. Some of the material is composed of fused fibrin and necrotic material with areas of infiltration with polymorphonuclear leucocytes and of fibroblasts indicating beginning organization. There is no evidence of tuberculosis. Diagnosis: acute and chronic inflammation."

The postoperative course was uneventful and the wound healed by first intention. A letter November 17, 1932 (nearly 3 years later), stated that the hand was in perfect condition.

S. S., P.M.H., 2647 (May 9, 1930–May 15, 1930). A student of 17 years entered the hospital because of a painful swelling over the right wrist and distal end of the radius. The onset dated back 3 years when she noticed a small swelling of the right wrist over the extensor tendon of the middle finger. The swelling was painless at the onset and gradually increased in size. About 6 months after the onset she noticed that when she held her hand in one position for a long time, pain was felt in the swelling, which by this time had attained the size of a half marble. Shortly after this the swelling began to cause her considerable discomfort and she consulted a surgeon who removed it. Soon after this operation the swelling recurred and has continued to increase in size until the time of admission. Six months before admission the tumor again became persistently painful. There was no history of respiratory disease nor were there any pulmonary or other findings suggestive of tuberculosis.

At examination there was found on the dorsum of the right hand, just distal to the carpus and over the extensor tendon of the middle finger, a soft, fluctuant, half-marble sized non-tender mass (Fig. 22, a, b, c). Just proximal to the wrist and in a direct line with the distal mass was a second, soft, fluctuant, but more diffuse swelling.

Operation May 10, 1930, revealed what appeared to be tuberculous granulation tissue surrounding the extensor tendons, some thick straw-colored encysted fluid in some of the sheaths, one rice body, and a slight beginning fragmentation. The granulomatous and scar tissues were carefully excised from around the tendons. The dorsal carpal ligament was sutured and the wound closed without drainage. The pathological report on this tissue stated that the inner surface of the tendon sheath was thrown into numerous villous processes containing areas of myxomatous degeneration and of infiltration with lymphocytes and plasma cells. No tubercles were seen and the diagnosis was a simple chronic tenosynovitis.

The operative wound healed nicely and the patient was discharged with the hand in a cock up splint to return for physiotherapy. The patient was again seen December 5, 1932, about 31 months following operation. She stated that she had perfect function of the hand, could play the piano, and that all movements were normal except for a slight tendency to extension of the index finger when she made a fist. There was no evidence on examination of any recurrence of the trouble (Fig. 22, d, e, f).

L. K., P.M.H., 9673 (March 6, 1932–March 13, 1932). A woman, aged 43, entered the hospital with the history that about 4½ years previously she had noted a swelling over the palmar surface of the proximal phalanx of the right ring finger. There were no signs of inflammation in the mass which slowly but progressively enlarged until it extended over the metacarpophalangeal joint into the palm. About a year later she consulted a physician who excised the portion of the swelling overlying the metacarpophalangeal joint and informed her that a cyst had been found. Since the operation the swelling has gradually increased until it covered the middle and proximal phalanges and the metacarpophalangeal joint. Although there has been progressive loss of function of the finger, there was no pain until 6 weeks previous to hospital admission when an aching pain developed over the medial side of the forearm and elbow. There was no history of any pulmonary disease in the family, and examination revealed none in the patient.

Examination of the hand (Fig. 23, a, b, c) showed a marked swelling of the middle and proximal phalanges of the ring finger, which gave the appearance of a spina ventosa. There was seen a 2 inch scar over the metacarpophalangeal joint and fluctuation could be detected on palpation over this area. There was marked disability of the finger in that there was but 20 degrees of flexion in the metacarpophalangeal

joint, 30 degress in the proximal interphalangeal joint which could be extended to 120 degrees, and no active flexion in the distal interphalangeal joint which was held in complete extension.

On March 7, 1932, under ethylene anæsthesia the old operative scar was excised and the incision enlarged so as to extend from the distal flexion crease of the finger proximalward into the palm to the transverse carpal ligament. Beneath the skin was a soft, bluish mass which looked like tortuous veins, but, upon cutting into it, it was found to be made up of soft grayish granulomatous tissue which involved the flexor tendons from the insertion upward to the wrist. This material also surrounded the tendons of the fifth finger and this sheath was therefore exposed in the finger and in the palm. The granulations were very difficult to remove from the tendons of the ring finger and it was necessary to excise the sublimis tendon. The little finger tendons were more easily freed. After all diseased tissue had been removed, bits of tendon were sewed over the proximal phalanges of the ring and little fingers to serve as transverse digital ligaments and the incision closed.

Microscopic examination of the excised tissue showed it to be made up of yellow lobulated masses of typical granulation tissue. No tubercles were seen.

Healing occurred promptly and the patient was discharged to return for dressings.

The patient returned April 9, 1933, because of extension of the process into the palm and wrist. She had noted a gradually increasing tumefaction just over and above the wrist which in the past 4 months had become more painful. There was no recurrence of the process in the ring and little fingers, though these fingers were still quite stiff especially in the interphalangeal joints (Fig. 23).

At operation (May 10, 1930, ethylene anæsthesia) a watery seropurulent fluid was found in the sheaths in the forearm and the sheaths themselves seemed more gelatinous and less fibrous than normal. The tendons of the little finger were intact but were bound down by fibrous adhesions, as were also the flexor tendons of the index and middle fingers though less so. The flexor pollicis longus was intact and its sheath was not involved. All of the diseased tissue was excised. The patient made an uneventful recovery and was discharged from the hospital on the fifth day.

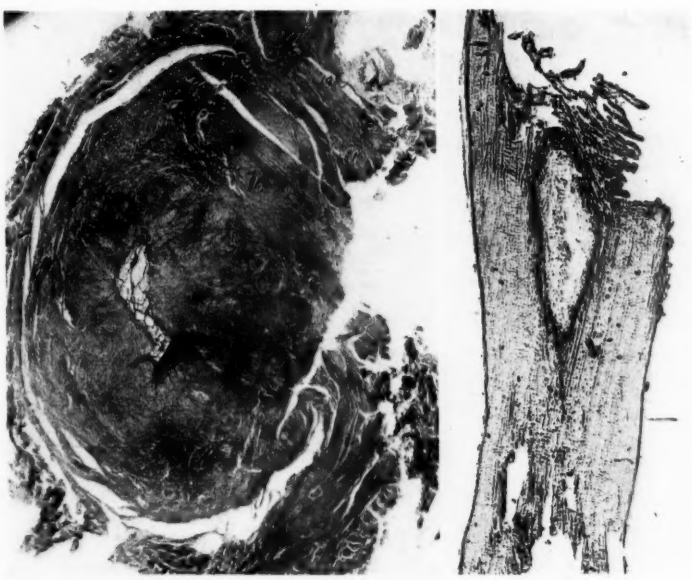
Microscopic sections showed dense, fibrous, rather highly vascular tissue with an abscess in one place surrounded by granulation tissue. There were no tubercles. A guinea-pig inoculation test made from the synovial exudate was negative for tuberculosis.

The 6 cases, of which the 3 just summarized are good examples, presented all the clinical characteristics of tuberculosis with the exception that in no case was there a history of trauma. Four of the patients were females (17, 41, 43, and 43 years of age, respectively) and 2 were males (50, 52 years of age); 4 had involvement of right hand and 2 of left; in 3 the volar sheaths and in 3 the dorsal sheaths. In 2 patients the condition was very early (both dorsal) and involved the sheath of the common extensors of the fingers and there was no extension into the sheath of the thumb tendons. In 3 cases the tendons were badly involved, so much in one instance that it was necessary to replace the flexor digitorum profundus to the middle finger with a tendon graft (Figs. 35, 36). In 5 cases rice bodies were present, once in very large numbers, in the others very few, in 1 case (Figs. 24, 25) as a large conglomerate mass measuring 8 by 20 by 40 millimeters. Pain was a prominent symptom in 2 instances and was the immediate reason for seeking operation, while in only 1 case was pain absent. In 1 case there was a recurrence and a second operation was necessary.

These cases are especially difficult to evaluate correctly. Even in proved instances of tuberculous tenosynovitis the histological picture may not be conclusive unless many sections are made and the correct areas chosen for examination. The guinea-pig test may even occasionally be negative in instances later proved to be tuberculosis by histological section. Since the non-specific group do not present any clinical or gross pathological features which distinguish it from tuberculosis we are inclined to believe a good proportion are in reality tuberculous, while the others belong to the same group of chronic inflammations as does the chronic bursitis.

TREATMENT

Tuberculosis of the tendon sheaths, if unaccompanied by active lesions elsewhere, is probably one of the least difficult of tuberculous processes in which to obtain complete cure. This may be secured either by conservative treatment such as removal of the melon seeds, injection of iodoform emulsion, and immobilization by splinting for a considerable period, or by complete surgical removal. The former method requires considerable time for its application, with consequent loss of use of the hand. As a result of prolonged immobilization, atrophy and contractures of the muscles take place, fibrous adhesions form about the joints, and these conditions are accentuated by the temporary loss of nerve function and by the involvement of the nerves in the pathological process itself. These results, how-



a. b.

Fig. 14. a, Cross section of tendon removed because of tuberculous infiltration. The sheath is obliterated and much of the tendon has been replaced by numerous confluent tubercles. b, Longitudinal section through a tendon showing central invasion by the tuberculous process.

ever, are usually transitory, and function is restored some weeks or months after removal of the splints. It may be advisable to combine active surgical intervention and immobilization in advanced cases, if the bones and joints are involved in the process.[1]

In Dr. Kanavel's paper there are reports of 3 patients treated by the conservative methods. Experience, however, early led him to abandon these procedures for radical excision, and in all the cases herewith reported surgery has been the method of treatment. In early stages or in those patients in whom the diagnosis may not be certain conservative therapy may be tried; however, in view of the tendon invasion which may occur it is not advisable to persist long with conservative measures unless improvement is apparent.

We have had no experience with roentgentherapy in this condition. Good results have been reported by a number of capable men, notable among whom are Wetterer (1920), Moll (1920), Iselin (1920), and Juengling (1922). The treatment, however, extends over a considerable period of time and we do not feel the results are as good as those obtained by adequate operative removal of the diseased sheaths.

[1]Kanavel, Surg., Gynec. & Obst. 1923, xxxvii, 635-647.

SURGICAL TREATMENT

The operation may be performed under local or general anæsthesia. Although in the earlier cases local anæsthesia was used almost exclusively, we have come more and more to the use of general anæsthesia. This has been done mainly for two reasons; the operation is long and tedious and outlasts both the duration of the anæsthetic and the endurance of the patient and secondly because the blood pressure apparatus which we use to maintain hæmostasis becomes almost unbearable after 40 to 50 minutes.

A bloodless field is secured by maintaining constriction with a blood pressure apparatus at about 220 to 230 millimeters of mercury. This pressure we have found can be maintained for as long as 90 minutes (in rare instances 2½ hours) without producing nerve injury. At the end of 90 minutes it is well to

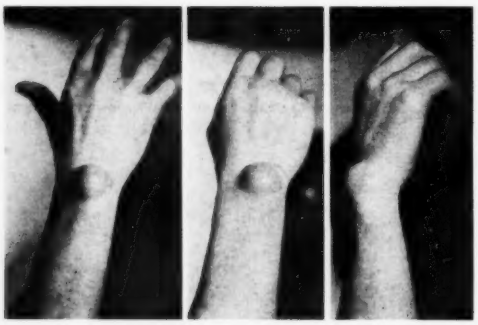


Fig. 15. Tuberculous tenosynovitis of dorsum of wrist, its globoid shape and tense consistency might easily lead to its being mistaken for ganglion.

release the pressure and care for all bleeding points, after which the cuff may be inflated again and the operation completed. It is wise at the close of the operation to let the pressure down, ligate bleeding points, and reinflate the cuff before closure of the wound. A snug pressure dressing with a large amount of fluffed-up gauze should be applied before the pressure is finally released. In this way we insure a dry operative field and prevent postoperative oozing.

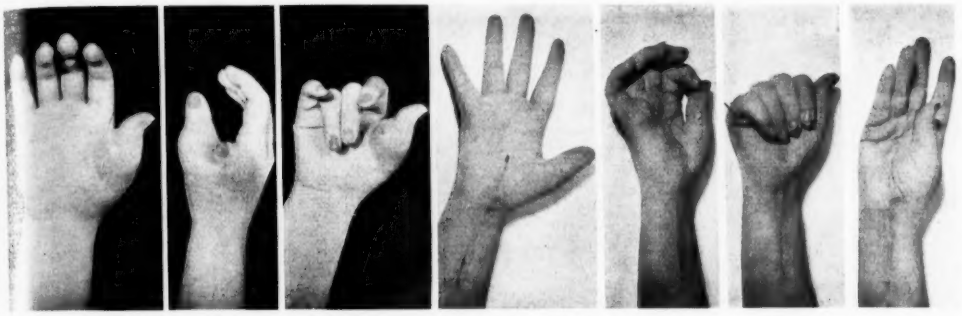
In the earlier cases the dissection was supplemented by splint immobilization for varying lengths of time. This period has been gradually shortened until now immobilization is not considered necessary except in those patients who may be suffering from a complication of the disease, such as bone or joint involvement or in whom tendon grafting or suture has been performed.

The incisions should be planned so as to avoid midline scars over the volar surfaces of the digits and to avoid transverse division of skin creases. It is wise also to plan the incision as much as possible in such a way as to raise flaps of skin which upon being replaced fall back over the denuded tendons, with the line of skin closure lying to one side.

Adequate exposure of the radial and ulnar bursæ with their digital prolongations into the thumb and little finger, respectively, requires two or three incisions. The main incision is a long one made in the palm, wrist, and forearm and exposes the whole of the ulnar bursa in the palm and above the wrist and the radial bursæ above the wrist (Fig. 26, a). This incision begins distally at the distal palmar crease and passes proximalward along the radial side of the hypothenar eminence to the midline of the wrist. At the wrist the incision curves ulnarward so as to cross the wrist transversely in the proximal skin crease and then passes up the forearm for about 3 inches curving gently toward the midline. The digital sheath of the fifth finger may then be exposed by an incision on the ulnar side of the finger which passes proximalward to the region of the metacarpophalangeal joint and then turns radialward for a short distance into the palm along the distal flexion crease. The sheath of the flexor longus pollicis is exposed by a third incision, along the radial side of the thenar eminence and thumb. In the proximal end of this incision, great care must be taken to avoid injury to the motor branch of the median nerve to the thenar muscles. The forearm and palmar incision may be varied (Fig. 26, b) by uncovering the radial bursa with one long incision starting on the ulnar side of the distal phalanx of the thumb, along the ulnar border of the thenar eminence, and then transversely across the wrist and longitudinally upward on the forearm. This incision is particularly of value in instances in which the radial bursa presents the most marked involvement. However, in any case it is essential to expose the entire extent of both major bursæ even if inspection at the wrist does not indicate the involvement of the digital prolongation of either bursa.

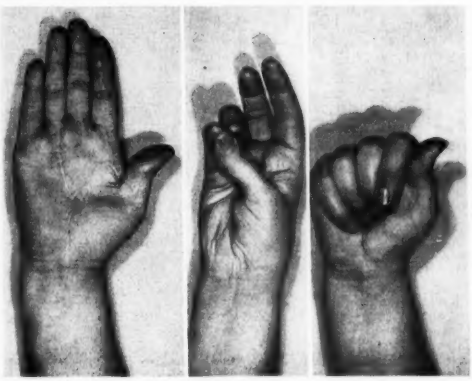
The incisions are carried down through the deep fascia and transverse carpal ligament where the involved sheaths will be found to bulge into the field (Fig. 27). The median nerve, swollen and compressed on top of the ulnar bursa, is carefully isolated, wrapped in sponges saturated in normal salt solution, and carefully retracted before the diseased tissue is touched. The superficial palmar arch lies across the surface of the bursa and it may be ligated and divided in order to obtain good exposure.

After a good exposure has been obtained the diseased tissue is excised, first from the tendons and then from the attachments to the surrounding tissues. The sheath is opened



a. b. c. d. e. f. g.

ig. 16. Tuberculous tenosynovitis of radial and ulnar sæ with sinus formation following aspiration. a, b, c, condition of the hand before operation. At operation entire extent of both radial and ulnar bursæ was found e invaded, with destruction of parts of the sublimis don of the little finger and invasion of the adductor pol- and first lumbrical muscle. d, e, f, g, The hand 5 nths after operation. There is still some drainage from sinus on the thumb. The sinus continued to drain for onths after operation and then ceased. h, i, j, Hand 2 rs 7 months after operation, sinus closed for 2 years, lling subsided, patient has good functional use of hand.



h. i. j.

ngitudinally and each tendon lifted up in rn and the visceral layer of the sheath dis- cted free from it (Fig. 28). This will leave e parietal layers of the sheath and the meso- non and thereto attached visceral sheaths fastened only to the fascia and muscles be- neath. After all the tendons have been freed of diseased tissue the infected sheaths may be removed as one or two large masses. In ex- cising this mass from the surrounding tissues it may be necessary to remove bits of deep fascia and muscles in order to remove all tuberculous tissue. When the dissection is completed the median nerve and the flexor tendons lie bare within the forearm, carpal tunnel, and palm. While within the forearm and palm there is a moderate amount of fatty subcutaneous tissue over the tendons, within the carpal tunnel the tendons are surrounded over fully three-fourths of their circumference by bony and dense fibrous walls. These ten- dons, however, develop new sheaths within which they glide easily, a fact attested both by functional results obtained and by observa- tion in cases requiring second operations. In such cases the tendons, which have remained free of recurrence, are surrounded by gray fibrous tissue through which they glide easily.

The tendons themselves frequently show invasion and it is necessary to excise the diseased portions (Fig. 29). If the invasion is not too extensive it may be possible to remove the infiltrated portions without damaging the tendon to any extent. However, in many in- stances tendons will be completely eroded or so badly fragmented as to require surgical removal. In such cases some sort of plastic repair is necessary.

In 10 cases such plastic repair was required. In 6 of these cases (with involvement of 10 tendons) the proximal and distal stumps of the destroyed tendons were sutured under slight tension to adjacent tendons (Fig. 29). In 1 case an end-to-end suture of the stumps of the extensor pollicis longus was made after excision of the involved tissue (Fig. 17). In 3 cases, however, such side-to-side suture was not possible and it was necessary to graft tendons into the defect. A tendon graft was used also in a fourth case of chronic non-

Fig. 17. Tuberculous tenosynovitis of the dorsum of the hand, especially marked on radial side. Involvement of extensor digitorum communis sheath, and sheaths of both extensors and long abductor of thumb. The long extensor tendon of thumb had separated and was sutured. At time of operation there was a focus of tuberculosis in the radius which was not touched. Following operation a sinus developed which was treated by immobilization and sunlight. Healing occurred in 9 months. a, b (Kanavel, *Surg., Gynec. & Obst.*, 1923, xxxvii, 635), The hand before operation in September, 1921. c, d, e, f, g, h, The hand in October, 1933. There has been no recurrence in the 12 years since operation.

tuberculous tenosynovitis. The results in all four instances have been satisfactory, and, since so far as we can determine they are the only recorded instances in which tendon grafts have been used in tuberculous tenosynovitis, we shall report here the history of these cases.

B. M., W.M.H. 134039, 137599, P.M.H. 708. A mechanic, 26 years of age, entered the hospital (October 28, 1917) because of trouble with his right wrist of 28 months' duration. The onset of this trouble dated back to June of 1925 when he sprained his wrist while turning a hand wheel at work. Almost at once following this injury a hard, tense, walnut-sized lump developed on the dorsum of the wrist. The skin over the mass was normal and movements of the wrist were well performed, but were associated with slight pain and weakness. The swelling at this time was diagnosed as a carpal ganglion. Six months later (December, 1925) the patient was operated upon, and 5 or 6 rice bodies were found. The operative wound healed and the patient returned to work with the hand and wrist immobilized on a splint. The swelling gradually recurred and was associated with more severe pain which at times became so marked that he would be awakened from sound sleep. At this time the weakness of the wrist was more marked though the finger movements were

a. b. c. d.

ig. 18. Tuberculous tenosynovitis of 18 months' dura-
ti with invasion of radial and ulnar bursæ with extension
ir the digital sheaths. One month before operation the
p ent felt the tendons to the index finger snap, since
w h time she was unable to flex the interphalangeal joints
o his finger. The tuberculous tissue was completely ex-
ci d and the distal stumps of the index finger tendons were
s ured to the corresponding tendons of the middle finger.
a , Before operation. c, d, Two and one-half years after
o ration. (Letter seven years after operation states the
h d gave her no trouble and there had been no recurrence.)
(I strated in Kanavel's original paper, *Surg., Gynec. & O .*, 1923, xxxvii, 635.)

n rmal. In the spring of 1926 a second operation w s performed at which time a sac-like structure c ntaining a little fluid but no rice bodies was re- m ved. Shortly after this operation the swelling a gain recurred and in the fall of 1926 a third oper- ation was performed and an extensive dissection carried out, multiple sac-like structures being re- moved. The operative wound healed after being kept open by packing for a period of 6 weeks. In the mid-summer of 1927 the pain and swelling again re- curred. Up to this time he could still use his hand at work but there was considerable weakness on supination and pronation. The pain was by this time quite severe and awakened him at 3 or 4 a. m.

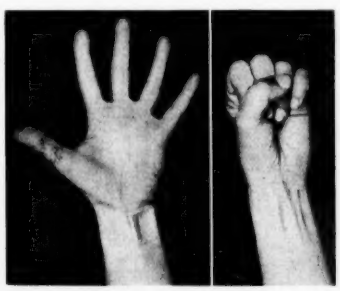


Fig. 20. Functional result 15 months after operation for tuberculous tenosynovitis of radial and ulnar bursæ of 1 year's duration. There was no tendon destruction. The operation was performed in May, 1926; these photographs were made in August, 1927. There had been no recurrence in October, 1933, 7 years and 5 months after operation.

a. b. c.

Fig. 19. Tuberculous tenosynovitis of entire radial bursa and of ulnar bursa without invasion of digital sheath in little finger. Destruction of sublimis tendons to ring and little fingers. The tuberculous tissue was excised and the stumps of the sublimis tendon to the ring finger were sutured proximally and distally to the corresponding tendons of the middle finger. The stumps of the sublimis tendon of the little finger were sutured to the profundus tendon of same finger. a, Before operation. b, c, Two and one-half years after operation. A communication 7 years and 10 months after operation states there has been no recurrence and that there has been no change since the last photographs were taken.

On admission, an egg-sized, irregular, tense swelling apparently connected with the extensor tendons presented itself on the dorsum of the right wrist (Fig. 30, a and b). An irregular, red, shiny scar marked the site of the last operation. The main area of tumefaction extended about 1.5 inches up into the forearm from the annular ligament and distally to about the middle of the metacarpals. The tumor appeared to be made up of a number of globular and elongated swellings. Along the extensor tendons of the thumb there could be seen and palpated an

Fig. 21. Chronic non-specific tenosynovitis of the dorsum of the hand.

a. b. c. d. e. f.

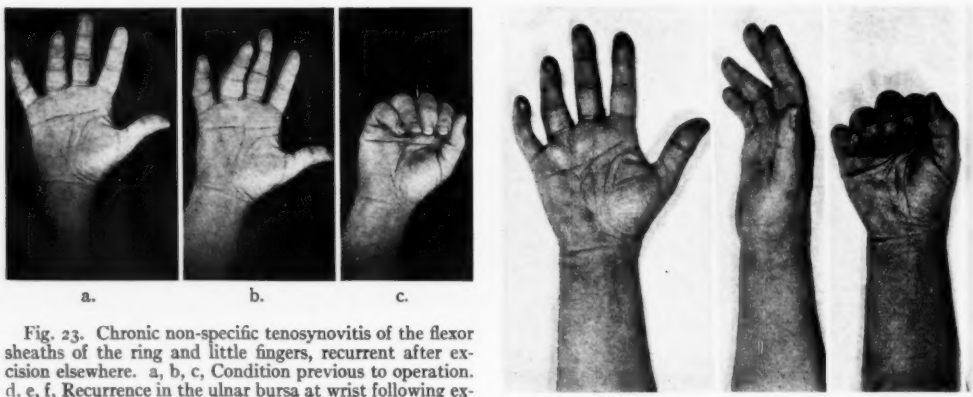
Fig. 22. Recurrent chronic non-specific tenosynovitis of the dorsal tendon sheaths. a, b, c, Before operation. d, e, f, nineteen months after operation.

elongated mass extending out from the main mass. Active extension was limited to the horizontal while passive extension was limited to about 20 degrees beyond horizontal. Active and passive flexion were limited to about 45 degrees. Movements of the fingers and thumb were not impaired. Palpation of the mass during motion yielded a "grating" sensation as if there were small shot in the wrist. Examination of the chest did not reveal any lung changes, and no other lesions were found.

Operation (October 29, 1927, local anæsthesia) revealed a mass of tuberculous tissue about 7 by 5 centimeters with rice bodies about the extensor tendons. The extensor tendons were taken singly and the tuberculous tissue removed from around each tendon by sharp dissection. A second incision was made over the extensors of the thumb. The pathological report of the tissue removed was "caseous and fibrous tuberculous tissue."

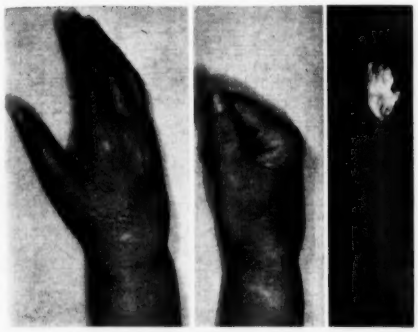
The immediate postoperative course was uneventful and the patient left the hospital with good use of his hand and wrist. After this operation there remained a small nodule on the dorsum of the wrist. The patient was advised to have this nodule watched carefully and to return if it became troublesome or increased in size. The patient returned to work and was able to use his hand without any difficulty. In the following 5 months the nodule noted above increased slightly in size and on advice of his physician the patient returned for another operation.

At this time (April 9, 1928, local anæsthesia) a long incision over the extensor tendons of the thumb showed the extensor pollicis longus and brevis tendons to be surrounded by a soft, in spots yellowish, granulation tissue. In one place for about three-fourths of an inch the superficial portion of the tendon of the extensor pollicis brevis appeared to be invaded. All of the granulation tissue and the visceral and parietal layers of the extensor sheaths were removed by clean dissection. The superficial involvement of the extensor pollicis brevis was excised to a depth of about 2 millimeters until normal healthy looking tendon was found. The pathological report on the tissue removed at this operation was



a. b. c. d. e. f.

Fig. 23. Chronic non-specific tenosynovitis of the flexor sheaths of the ring and little fingers, recurrent after excision elsewhere. a, b, c, Condition previous to operation. d, e, f, Recurrence in the ulnar bursa at wrist following extensive excision 1 year previously.



ig. 24. Chronic tenosynovitis of 3 years' duration in- ving all of the extensor tendon sheaths on the dorsum of ight wrist. Marked swelling and almost continuous pa . Tendons quite thin but not destroyed. Photograph sh vs the condition of the hand before operation. The inset is photograph of single large rice body 8 by 20 by 40 m imeters. (The white line is 4 centimeters long.)

Fig. 25. Drawing made at operation of hand illustrated in Figure 24. The sheath of the common extensors is shown with the constriction produced in it by the dorsal carpal ligament. The radial extensors and the extensors and long abductor of the thumb have not yet been exposed. The large rice body was found lying in the distended sheaths over the metacarpus.

" ronically inflamed fibrous tissue containing nu- m ous foreign body giant cells. In places the giant ce s were grouped around fragments of foreign m terial."

he postoperative course was uneventful, the op rative wound healed by first intention, and the pa ient returned to work while continuing post- op rative ultraviolet therapy.

Following this operation he had perfect use of his h nd which was gradually getting stronger and did no cause him any discomfort or trouble for some 16 months, that is, until August of 1929. At this time a firm swelling again appeared along the extensor tendons of the thumb. Extension of the thumb was limited and associated with some pain. Examination showed a firm rope-like swelling along the course of the extensor pollicis longus, which was not tender or red. Flexion of the thumb was possible but extension was imperfect.

In October of 1929 (October 3, 1929, local anæsthesia) he was again operated upon and the old skin scar over the extensor pollicis longus removed. The underlying tendon of the extensor pollicis longus was found large, soft, and swollen, especially over the distal end of the carpus. It was infiltrated with grayish-yellow tissue and had ruptured about midway between the muscle and the first metacarpophalangeal joint. The portion of the tendon lying between the muscle belly and the metacarpophalangeal joint was excised and was replaced by a tendon graft (Fig. 31). The tendon of the extensor digitorum communis of the third right toe, with all its sheath was excised for about 3 inches and grafted into position between the proximal and distal stumps of the extensor pollicis longus. The muscle belly of the abductor pollicis longus was pulled under the proximal line of suture to serve as gliding tissue and to prevent binding adhesions. The tendon of the extensor pollicis brevis could not be found. The pathological report on the piece of excised tendon stated that for a distance of about 6.5 centimeters in the central part, the tendon was covered by an adherent, yellowish gelatinous mass of ragged and irregular tissue (Fig. 14, a). The ends of the tendon appeared normal. A considerable portion of the tendon had been replaced by numerous confluent tubercles. The patient made an uneventful recovery and was discharged after physiotherapy had been begun.

One month after operation, the new tendon was seen to be functioning perfectly (Fig. 30, c, d). Examination of the hand 1 year after operation showed no evidence of recurrence (Fig. 30, e, f, g). The new tendon had healed nicely into position and was functioning perfectly. It could be felt and seen under the skin as a tough, hard movable strand of tissue not unlike a normal tendon. Report from the patient 4 years after the last operation stated that there had been no recurrence and that he was using his hand in his work.

T. S., P.M.H. 6102. A home girl, 31 years of age, entered the hospital March 14, 1931, because of a painful swelling of the right wrist and inability to flex the little and index fingers. There was a suspicion of a sprain but no definite history of trauma. At the onset, 4 years previously, she noted pain and swelling of the volar aspect of the right wrist. After using the wrist the pain became much worse and the swelling larger and more tense. This condition persisted essentially unchanged for 2 years when she noted that she was beginning to lose ability to flex the two distal joints of the index finger. A light cast was applied and the pain and swelling gradually subsided, but she began to lose ability to flex the little finger and when the cast was removed she was unable to flex the interphalangeal joints of this finger. At times she thought that she had a slight rise in temperature. Familial history was positive in

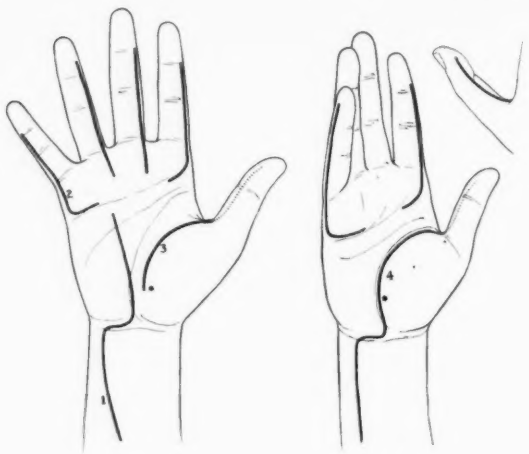


Fig. 26. Diagrams illustrating the types of incisions used to expose the volar tendon sheaths. Adequate exposure of radial and ulnar bursæ requires 2 or 3 incisions (see text). In (a) the ulnar bursa proper is exposed by incision *1* and its digital prolongation by incision *2*. The radial bursa is exposed by a supplementary incision *3* along the ulnar border of the thenar eminence and thumb. The distal end of this incision is shown in the insert. The proximal end of the incision must stop a thumb's breadth proximal to the transverse carpal ligament to avoid the motor branch of the median nerve to the thenar muscles. The incisions for the digital sheaths are also indicated. If the radial bursa is the most involved (b) the main incision *4* may be made along the thenar eminence and pass transversely across the wrist. The motor nerve to the thenar muscles must be identified and protected.

that her mother had died of tuberculosis of the spine. She complained of a chronic cough for the past two winters and stated that the sputum was occasionally tinged with blood. Following removal of the tonsils, however, the cough improved considerably and the blood spotting of the sputum disappeared. Two years previously she had an attack of pain in the right upper quadrant of the abdomen associated with vomiting and jaundice. Since this attack she has been troubled with frequent abdominal discomfort and vomiting. This syndrome was taken to indicate a chronic cholecystitis. General physical examination showed some slight tenderness over the region of the gall bladder. The lungs were clear.

There was a slight, soft, fluctuant, non-tender swelling just above the transverse carpal ligament extending across the volar surface at the lower end of the forearm (Fig. 32, a, b, c, d). There was some atrophy of the right arm, forearm, and hand. She was unable to flex the index or little fingers at the interphalangeal joints.

At operation (April 15, 1931, ethylene anæsthesia) there was found a tuberculous involvement of the sheaths of all flexor tendons from the beginning of the tendons above to the level of the middle flexion crease in the palm below. The tendons of the index finger were completely eroded. Where the common flexor sheath began distally, the flexors of the index finger within the sheath were transformed into a yellow caseous mass (Fig. 8). Just outside the sheath the tendons appeared normal, but in section there could be seen central destruction. The destruction began distally at the middle flexion crease in the palm and extended proximally to the beginning of the muscle. The destruction of the sublimis tendon was a little more extensive than that of the profundus tendon. The tendons of the little finger were destroyed over an area about two-thirds as great as the tendon of the index finger. The tendons of the thumb, middle, and ring fingers were frayed but their continuity was not interrupted. Within the tuberculous synovial sac were many loculi some of them filled with a soft gelatinous material which looked as though it were an early stage in rice body formation, but none of them contained free fluid or rice bodies. The tuberculous tissue including the destroyed and invaded tendons of the index and little fingers were completely excised. The defects in the tendons were repaired by the use of tendon graft

(Fig. 33). The distal stumps of the profundus and sublimis tendons of the index finger were sutured together near the base of the finger and the two proximal stumps were united side by side above the wrist. The gap between these stumps was bridged by a graft of palmaris longus tendon. The gap between the stumps of the flexor tendons of the little finger was similarly united by means of tendon taken from the palmaris longus. In this case, however, only the stumps of the profundus tendon were united. The transverse carpal ligament was sutured, the wound closed, a pressure dressing applied, and the hand placed on a flexion splint. Pathological study of the portion of tendons removed revealed a completely necrotic area surrounded by a narrow zone of infiltration with lymphocytes and beginning organization of the necrotic area (Fig. 14, b).

The postoperative course was uneventful and the patient left the hospital with beginning return of active movements.

Examination of the hand on July 3, 1931, about 3 months after operation, showed the incision completely healed, and the function of the fingers returning. A second examination in February, 1932, showed the further return of function in the fingers. A third examination in October, 1933, 2 years and 7 months after operation, showed no recurrence and increasing ability to use the hand (Fig. 32, e, f, g, h).

J. T., P.M.H. 6777. A coal miner of 55 was struck on the palm of his left hand by a falling rock some 15 months previously. The swelling which followed this injury slowly increased and was soon accompanied by pain and considerable disability. Six months previous to admission to the hospital, he was operated upon elsewhere and some of the exuberant tissue excised. Following this operation there was no improvement, a sinus developed and the pain and swelling failed to subside. Upon entrance to the hospital there were found a midline scar on the volar surface of the left wrist and forearm, a draining sinus at the lower end of the incision, and two other sinuses over the thenar eminence. There was moderate non-tender swelling of the wrist, and considerable limitation of flexion of all the fingers. The interphalangeal joints of the little finger could not be actively flexed. At operation there was found to be marked involvement of the ulnar and radial bursæ at the wrist and in the palm, with invasion of the interosseous fascia and adductor pollicis muscle. The flexor digitorum sublimis to the index finger and the two flexor tendons to the little finger were found to have been destroyed from the level of the wrist to the distal flexion crease in the palm. The distal stump of the sublimis tendon to the index finger was sutured to the corresponding profundus tendon. The flexor tendons to the little finger were repaired by a transference of palmaris longus tendon in the following manner. The palmaris longus was detached from its insertion and united end-to-end to both distal stumps of the little finger tendons (Fig. 34). The proximal end of the sublimis of the fifth finger was united side-to-side to the palmaris

Fig. 27. The incision passes through the skin and fascia and divides the transverse carpal ligament, exposing the distended ulnar bursa upon the surface of which lies the median nerve, which may be entirely surrounded by inflammatory tissue. (From Kanavel, *Surg., Gynec. & Obst.*, 1923, xxxvii, 635.)

longus. The postoperative healing was complicated by drainage from the regions of the old sinuses and it took several weeks to secure complete closure. However, at the end of 2¼ years the patient reports that the hand is healed though somewhat weak and that he has been back at work.

The last case is not a proved tuberculosis.

R. P., P.M.H. 15087. A female of 43 was admitted to Northwestern University Dispensary complaining of pain and swelling on the volar surface of the right wrist and hand of 3 years' duration (Fig. 36, a, b). At operation a marked involvement of the ulnar bursa in the wrist and palm was found, without invasion of the radial bursa in the wrist or thumb, or of the digital prolongation of the ulnar bursa. The profundus tendon to the middle finger was so badly invaded that it required excision from the proximal end of the bursa nearly to the heads of the

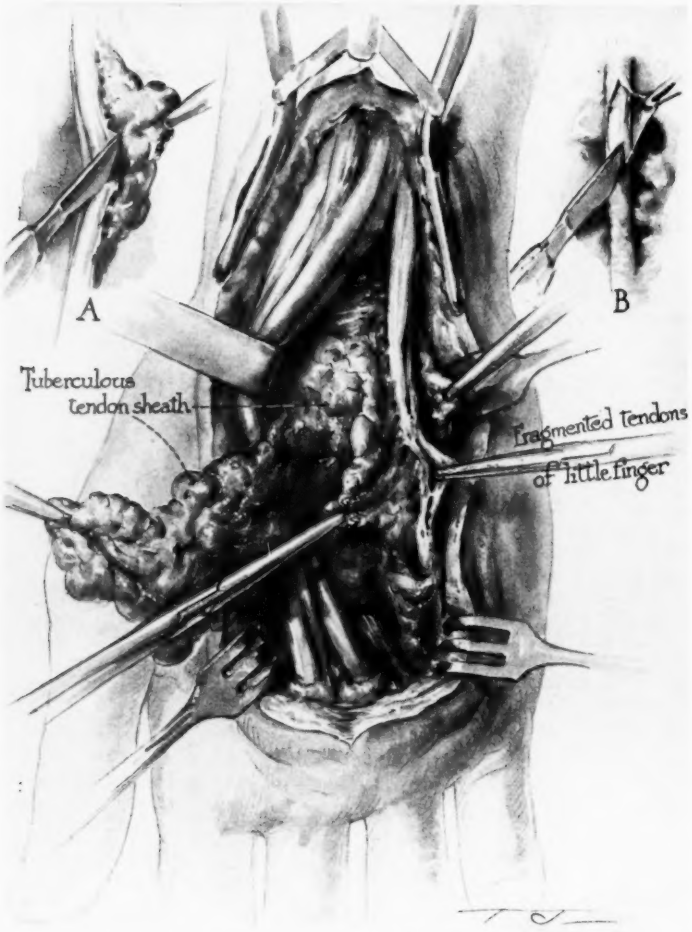


Fig. 28. After the median nerve has been isolated and carefully retracted each tendon is taken in turn and the tuberculous tissue dissected free from it, taking especial care that the visceral sheath, *B*, is entirely removed. (From Kanavel, *Surg., Gynec. & Obst.*, 1923, xxxvii, 635.)

metacarpals. The other deep tendons were also frayed in the carpal tunnel, but could be saved. The destroyed segment of the profundus to the middle finger was replaced by a free graft taken from the palmaris longus (Fig. 35). Healing occurred *per primam* and the functional result is satisfactory (Fig. 36, c, d, e, f).

In excising the involved sheaths of the individual fingers incisions are made along either the radial or ulnar border of the finger from the distal interphalangeal joint upward into the palm alongside the metacarpophalangeal joint where the proximal cul-de-sac of the sheath is reached (Fig. 26, a and b). If possible we attempt to preserve a bridge of fibrous tissue over the base of the proximal phalanx and over the middle of the middle phalanx to serve as transverse ligaments to prevent herniation of the tendons. This, however, is seldom possible since the fibrous sheath is practically always invaded and requires excision. We are accustomed in such cases to fashion transverse digital ligaments

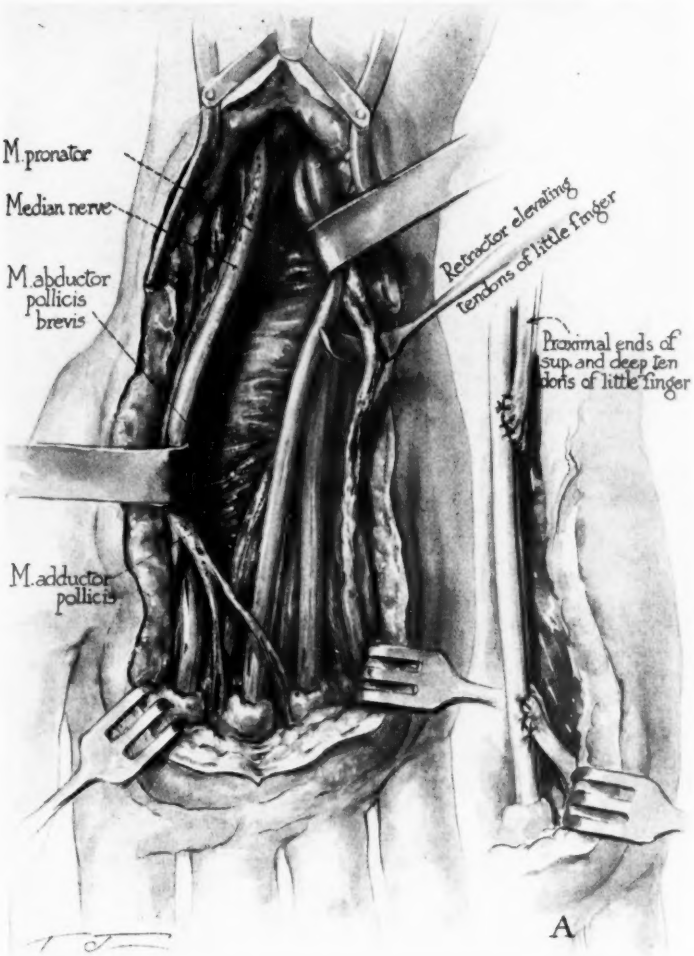
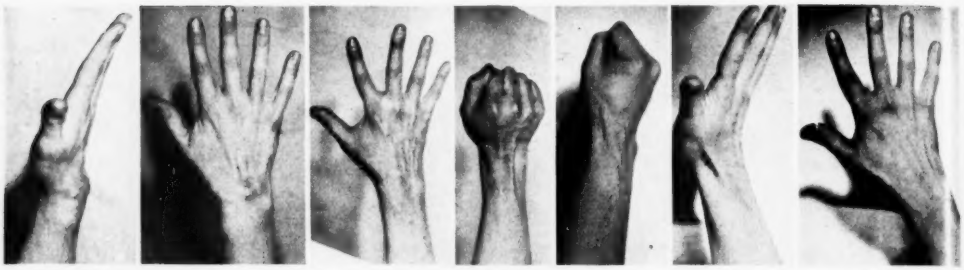

M. pronator
Median nerve
M. abductor pollicis brevis
M. adductor pollicis
Retractor elevating tendons of little finger
Proximal ends of sup. and deep tendons of little finger
A

Fig. 29. Every vestige of diseased tissue is removed so that at the completion of the operation the bare tendons lie upon the muscles and fascia of the palm and forearm. It may be necessary to remove badly fragmented tendons. These may be repaired by suturing the stumps to adjacent tendons, *A*. (From Kanavel, *Surg., Gynec. & Obst.*, 1923, xxxvii, 635.)

(Koch) from bits of tendon tissue excised from the palmaris longus tendon or from remnants of attachments of the sublimis tendon. These are sutured to the fibrous tissue along the sides of the bone across the flexor tendons and serve as ligaments to keep these tendons in apposition to the bone. This procedure we have carried out in 5 or 6 cases and have been quite satisfied with it.

At the completion of the operation the blood pressure cuff is deflated and all bleeding points stopped. The pressure is again applied and the incision is closed. Some fine silk sutures are placed in the superficial fascia and the skin closed with fine silk or other fine skin sutures. Great care is taken to obtain as accurate an apposition of the skin edges as possible. Small rubber strips may be inserted in a few



a b. c. d. e. f. g.

Fig. 30. Tuberculous tenosynovitis of dorsum of hand, history of patient given in full in text. a, b, Condition of hand previous to first operation. This patient had been operated upon three times elsewhere and scars from these operations are visible. c, d, The condition of the hand 1 month following tendon graft to replace the extensor pollicis longus which had been completely destroyed. This grafted tendon functions perfectly and stands out prominently on the radial side. e, f, g, The hand 1 year following tendon graft. (Four years after operation the patient writes that there has been no recurrence and that he has good use of his hand.)

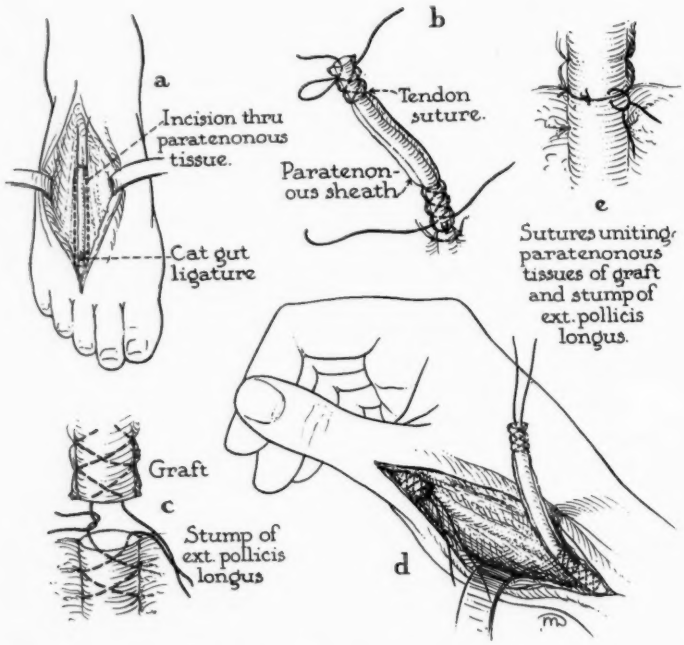
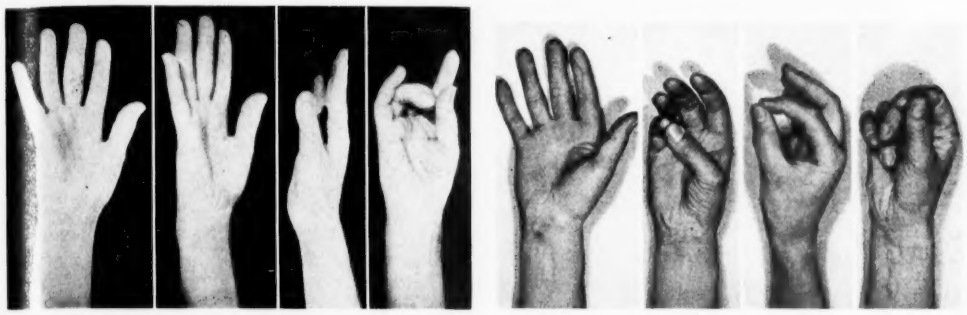


Fig. 31. Same patient as in Figure 30. Tendon transplantation for repair of extensor pollicis longus destroyed by tuberculosis. a, Extensor tendon of foot exposed, leaving paratenonous tissues about it. Longitudinal incisions are made to either side of the tendon through the paratenonous tissues. At either end of these incisions catgut ligatures are passed around the tendon and tied in order to keep the tissues attached to the tendon. b, Sutures passed through tendon and paratenonous tissues. After the suture is made the catgut ligature and the tendon it surrounds are excised. c, e, Details of suture lines. In (e) the suture of paratenonous tissues is shown. d, Suture at proximal line completed.



a. b. c. d. e. f. g. h.

Fig. 32. Tuberculous tenosynovitis of radial and ulnar bursæ with destruction of both flexor tendons of index and little fingers. These tendons were replaced by a graft of palmaris longus tendon. a, b, c, d, The hand before operation. The limited flexion of the index and little fingers is evident. e, f, g, h, Two years and 6 months after removal of tuberculous sheaths and replacement of destroyed tendons by tendon grafts.

plates to serve as drains. No splint is applied unless tendon repair indicates necessity for immobilization, in which case the after-care is practically the same as for tendon repair.

The treatment of dorsal tuberculosis is the same as that of the volar variety. The incisions here should be made so as to expose the sheaths adequately, and to produce a flap if possible. Since the extensor pollicis sheaths are practically always found to be infected even in those instances in which there is no external evidence of it, it is well to make the incision toward the radial side. The incision may start over the dorsum of the first inter-

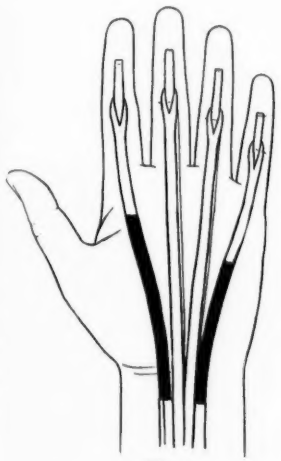


Fig. 33.

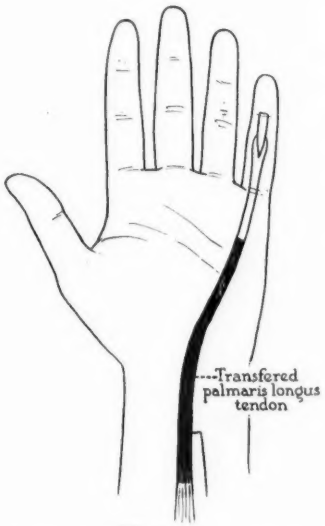


Fig. 34.

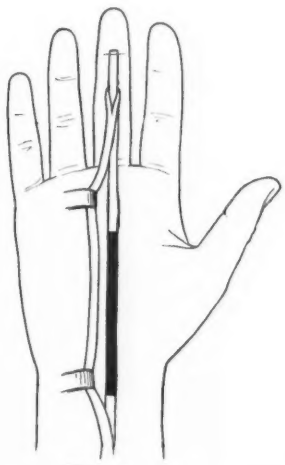
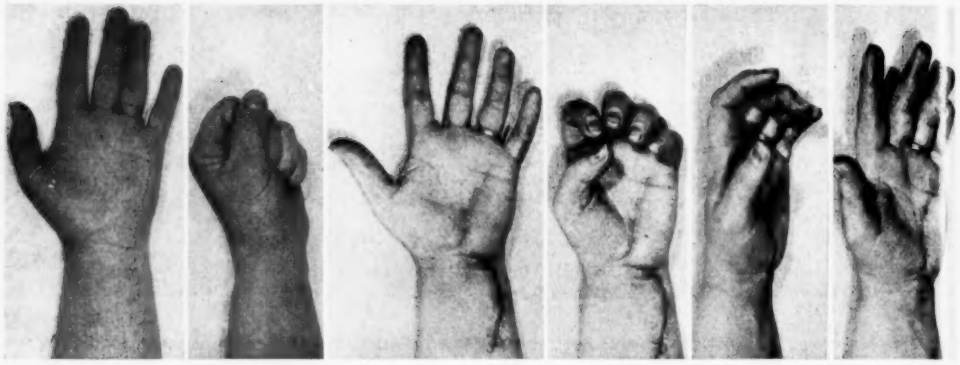


Fig. 35.

Fig. 33. Same patient as in Figure 32. The flexor tendons of the index and little fingers were replaced by tendon grafts taken from the palmaris longus.

Fig. 34. Tuberculous tenosynovitis with secondary infection. The destroyed flexor tendons to the little finger were replaced by a transference of the palmaris longus tendon. Healing occurred in spite of a postoperative reaction.

Fig. 35. Same patient as in Figure 36. The flexor digitorum profundus to the middle finger was so badly invaded and frayed that it was replaced by a graft taken from the palmaris longus.



a. b. c. d. e. f.

Fig. 36. Chronic tenosynovitis of radial and ulnar bursæ without extension into digital prolongations. Major complaint was of pain. a, b, Hand before operation. c, d. e, f, Condition of the hand 8 weeks after operation. The grafted flexor profundus to the middle finger is functioning nicely.

osseus space to the ulnar side of the extensor pollicis longus tendon, pass upward toward the carpus, and then turn ulnarward transversely across the carpus to pass proximalward again slightly to the ulnar side of the midline for about 3 inches into the forearm.

In case of the dorsal sheath it must be kept in mind that there are multiple canals on the dorsum of the wrist through which the various tendons pass. Each of these compartments must be opened and explored and all involved tissue including the dorsal carpal ligament must be excised. It is always advisable to explore the tendon sheaths of the extensor pollicis longus, brevis and abductor pollicis longus since our experience shows that these are always invaded. At the close of the operation a new dorsal carpal ligament can be fashioned from surrounding fibrous tissue. The extensor pollicis longus which lies to the ulnar side of a ridge on the dorsal surface of the radius should be replaced in this groove and held there by suturing fibrous tissue across it.

AFTER-CARE

Unless definite indications arise the initial dressing is not changed for 48 to 72 hours. Thus we do not disturb the original hæmostatic pressure of the postoperative dressing, and the wound is kept free of blood and serum. At the first dressing the rubber strips are removed and another fluffed gauze pressure dressing applied. The pressure dressings are kept up for 5 to 6 days when they may be discontinued and lighter dressings applied. Sutures as in other work dealing with the hand are not removed for 12 to 14 days. This applies particularly to the palm of the hand.

Physical therapy is not used routinely in the after-care. The patient is told to use the hand for light uses as soon as it has healed and is encouraged to spend time in the sunlight and fresh air. If good use does not seem to be returning after 6 to 8 weeks, we may advise physical therapy, heat, massage, active, and passive motion for a short time. However, our feeling is that such procedures are usually unnecessary and probably in view of the nature of the condition are not indicated.

REFERENCES

ALBERTINI, A. V. Handbuch der speziellen pathologischen Anatomie und Histologie. Henke-Lubarsch. Vol. ix, part 1. Berlin: Julius Springer, 1929.

ANTONGIOVANNI, G. B. Cysts and tuberculosis of tendon sheath. Policlin., Roma, 1922, xxix (sez. prat.), 541–544.

BEACH, H. H. A. Tuberculosis of sheath of extensor tendons of foot; operation. Boston M. & S. J., 1889, cxx, 559.

BECCHERLE, G. Su di un caso di tubercolosi pseudoneoplastica delle guaine tendinee. Policlin., Roma, 1914, xxi (sez. chir.), 127–133.

BEGER, A. Die Tuberculose der Sehnenscheiden. Deutsche Ztschr. f. Chir., 1884–1885, xxi, 335–350.

BILLE, E. Ueber das Hygroma proliferum palmare. Inaugural Dissertation, Leipzig, 1866.

BRIENS, L. Étude clinique sur les synovites tuberculeuses primitives de la gaine tendineuse commune des peroniers lateraux. Paris, 1899, No. 383.

CAWSTON, F. G. Tuberculous tenosynovitis in a rheumatic subject. South Africa M. Rec., 1924, xxii, 432.

CHAPUT. Tuberculose de la gaine des flechisseurs et de l'articulation du poignet justiciable de l'amputation; traitement par la méthode de Bier; guérison avec conservation des mouvements. Bull. et mém. Soc. de chir. de Par., 1906, n.s., xxxii, 804.

Ide[illegible]. Tuberculose traumatique des gaines palmaires; traitement par la méthode de Bier; amelioration rapide. Bull. et mém. Soc. de chir. de Par., 1908, n.s., xxxiv, 23.

Ide[illegible]. Tuberculose des gaines palmaires guérie par la méthode de Bier. Bull. et mém. Soc. de chir. de Par., 1908, n.s., xxxiv, 532.

CLERMONT, P., WINTERSTEIN, O., and DIMTZA, A. Die Chirurgie der Tuberkulose. Berlin: S. Karger, 1931.

COLTON, F. J. Tuberculosis of palmar tendon sheaths. Surg. Clin. N. America, 1921, i, 905.

CURTIS, B. F. Tuberculosis of tendons. Ann. Surg., 1898, xxviii, 384.

DELBET, P. Tuberculose de la main traitée par la méthode de Bier. Bull. et mém. Soc. de chir. de Par., 1905, n.s., xxxi, 997.

DIETERICH, H. Diagnosis of tuberculosis of sheaths of tendons of hand. Muenchen. med. Wchnschr., 1925, lxxii, 693–694.

DUDLEY, E. Tuberculosis of tendons and of tendon sheaths. Texas Cour.-Rec. Med., 1904–1905, xxii, 1–6.

FEIL, E. Ein Fall von Sehnenscheidentuberculose geheilt durch Landerersche Hetolinjektionen. Deutsche med. Wchnschr., 1905, xxxi, 1035.

FOOTE, M. N. Tuberculosis of tendon sheaths of hand; 3 cases. Long Island M. J., 1927, xxi, 586–588.

FORGUE, E., and MASSABUAU, G. La forme hypertrophique pseudoneoplasique de la tuberculose des gaines tendineuses. Presse méd., 1909, xvii, 745–747.

FREIBERG, A. H. Bodies from case of tendon sheath tuberculosis. Cincin. Lancet-Clinic, 1899, n.s., xlii, 294.

GARRÉ, C. Die primaere tuberkuloese Sehnenscheidenentzuendung. Beitr. z. klin. Chir., 1890–1891, vii, 293–366.

GERSTER, A. G. Tubercular synovitis of the sheaths of tendons. Med. Rec., 1887, xxxi, 277.

GILLIES, A. Tuberculous tenosynovitis of palmar synovial bursa: "compound palmar ganglion"; case report. J. Bone & Joint Surg., 1931, xxix, 156–157.

GOLDING-BIRD, C. H. Case of tubercular tenosynovitis. Tr. Path. Soc. Lond., 1888–1889, xl, 244.

GOLDMANN, E. Die Bildungsweise der Reiskoerperchen in tuberkuloes erkrankten Gelenken, Schleimbeuteln und Sehnenscheiden. Beitr. z. klin. Chir., 1896, xv, 757.

GOUGEROT, H. Kyste synovial et tuberculose, maladie polykystique tuberculeuse du poignet; inoculation positive du liquide au cobaye. Paris méd., 1921, xli, 333–336.

GUENTHER, H. Ueber multiple symmetrische Erkrankungen der Sehnenscheiden und Schleimbeutel, besonders die Hygromatosis rheumatica. Deutsche Arch. f. klin. Med., 1913, cix, 252–270.

HASENKNOPF, H. F. B. Ueber Sehnenscheidentuberculose. Berlin, 1892.

HAUCK, G. Ueber akute und chronische Tendovaginitis und ihre Behandlung. Arch. f. klin. Chir., 1925, cxxxvi, 161–189.

HAYWARD. Tuberculosis of tendon sheaths; surgical therapy. Med. Klin., 1931, xxvii, 1721–1722.

HOEFTMANN, H. Ueber Ganglien und chronisch fungoese Sehnenscheiden-Entzuendung. Inaugural Dissertation, Koenigsberg in Pr., J. Jacoby, 1876.

HOPP, A. Beitraege zur Lehre von den Sehnenscheidenentzuendungen, besonders der chronisch fungoesen an der untern Extremitaet. Inaugural Dissertation, Berlin, G. Schade, 1886.

HORHAND, R. Tuberculose inflammatoire de l'aponevrose palmaire; inflexion permanente du petit doigt, et parfois, des doigts voisins, d'origine tuberculeuse. Lyon méd., 1907, cviii, 445–456.

HUSSY, A. Ueber die Erfolge der Heliotherapie im Hochgebirge bei Tuberkulosen der Hand. Festschr. H. Bircher, Tuebing, 1914, 484–523.

ISELIN, H. Roentgenbehandlung der chirurgischen Tuberkulose. Strahlentherapie, 1920, x, 651.

JAMIN, R. Synovite tuberculeuse des gaines tendineuses. Bull. Soc. anat. de Par., 1882, lvii, 119–122. (Rap. de Segond), 153–156; Progrès méd., Par., 1882, x, 359; 821 (Rap. de Segond), 1010.

JARDET and NOTTA, M. Synovite tuberculeuse primitive des gaines tendineuses du poignet et de la main; tumeur en bissac; extirpation et drainage de la poche; guérison. Bull. Soc. anat. de Par., 1885, lx, 408–410.

JUENGLING, O. Roentgenbehandlung in der Chirurgie. Strahlentherapie, 1922–1923, xiv, 761–799.

KAISER, F. Zur Kenntnis der primaeren Muskeltuberkulose. Arch. f. klin. Chir., 1905, lxxvii, 1033.

KANAVEL, A. B. Tuberculous tenosynovitis of the hand; a report of fourteen cases of tuberculous tenosynovitis. Surg., Gynec. & Obst., 1923, xxxvii, 635–647; Tr. Am. Surg. Ass., 1923, xli, 393–420.

KAUFMANN, MAX. Ueber die Natur der Corpora Oryzoidea. Inaugural Dissertation, Wuerzberg, 1886.

KOCH, S. L. Complicated contractures of the hand. Their treatment by freeing fibrosed tendons and replacing destroyed tendons with grafts. Ann. Surg., 1933, xcviii, 546–580.

KRECHEL, H. Ueber die Reiskoerperbildungen in den Hygromen. Inaugural Dissertation, Bonn, 1890.

KOENIG, F. Die Bedeutung des Faserstoffes fuer die pathologisch-anatomische und die klinische Entwicklung der Gelenk und Sehnenscheiden Tuberkulose. Centralbl. f. Chir., 1886, xiii, 425.

LANCEREAUX. Synovite tuberculeuse des tendons des doigts de la main. Bull. Soc. anat. de Par., 1873, xlviii, 617.

MARCHAND, F. Zur Kenntniss der fibrinoesen Exsudation bei Entzuendungen (Reply to E. Neumann). Arch. f. path. Anat., 1896, cxlv, 279–316.

MAUG. Hydatids of the palm of the hand. J. de Progress, etc. Abstracted in Monthly J. Foreign Med., 1828, ii, 472.

MAYER, M. L. Ueber maligne Geschwuelste der Sehnenscheiden. Inaugural Dissertation, Wuerzberg, 1886.

MEYER. Tuberculosis of sheaths of flexor tendons of forearm and hand; radical extirpation. Ann. Surg., 1922, lxxvi, 791.

MEYER, W. Tuberculous tenosynovitis. Ann. Surg., 1920, lxxii, 376.

MICHON, L. M. Des tumeurs synoviales de la partie inférieure de l'avant bras, de la face palmaire du poignet et de la main. Thèse de doct., Par., 1851.

MILIAN and CREPIN. La camptodactylie, tuberculose sclé reuse des tendons. Bull. et mém. Soc. méd. d. hôp. de Par., 1908, 3. s. xxv, 21–27.

MILLER, M. B. Primary tuberculosis of the tendons of the peroneus longus and brevis. Ann. Surg., 1912, lvi, 494–496.

MOLL K. Erfolge der Roentgentiefentherapie bei chirurgischer Tuberkulose. Beitr. z. klin. Chir., 1920, cxviii, 445.

MUEHSAM. Impftuberkulose der Sehnenscheiden beim Pflegepersonal. Deutsche med. Wchnschr., 1908, xxxiv, 484.

MUELLER C. F. O. Ueber tuberkulose Sehnenscheidenentzuendung. Inaugural Dissertation, Wuerzberg, 1887.

MUELLER, G. P. Tuberculous tenovaginitis; two cases. Ann. Surg., 1912, lvi, 496–498.

MUELLER, WALTHER. Die Chirurgie der Muskeln, Sehnen und Fascien. Die Chirurgie: Eine zusammenfassende Darstellung der allgemeinen und der speziellen Chirurgie. Edited by M. Kirschner and O. Nordmann. Vol. ii. 2d part. Berlin, Vienna: Urban and Schwarzenberg, 1930.

MURARD, J. Kystes du poignet et tuberculose. Presse méd., Par., 1920, xxviii, 304.

MURPHY, J. B. Tuberculous tenosynovitis of palmar synovial bursa; injection of Calot's solution. Surg. Clin., 1916, v, 295–299.

Idem. Tuberculous tenosynovitis of peroneal tendons; (1) injections of Calot's solution; (2) incision, excision of synovial membrane, making of new sheath from fatty tissue. Surg. Clin., 1916, v, 1165–1167.

NICAISE, POULET, and VAILLARD. Nature tuberculeuse des hygromes et des synovites tendineuses. Rev. de Chir., 1885, v, 609.

NOMMEL. Drei Faelle von Tendovaginitis fungosa an den Fingern. Inaugural Dissertation, Wuerzberg, 1896.

ORR, T. G. Tuberculous tenosynovitis of dorsum of hand. J. Kansas M. Soc., 1923, xxiii, 349–350.

ORT, M. Case of tuberculous inflammation of synovial membrane. Časop. lék. česk., 1928, xii, 438–440.

PAITRE and BRUAS. Kystes synoviaux du poignet et tuberculose. Soc. de méd. mil. franç. Bull., 1926, xx, 128–131.

POUPELLE, C. De la synovite tuberculeuse des gaines tendineuses. Paris, 1883.

VON SCHILLER, K. Wegen Sehnenscheidentuberkulose ausgefuehrte Muskelsehn resektion; Tendomusculoanastomosis; Heilung mit vollkommener Funktion. Zentralbl. f. Chir., 1908, xxxv, 503; Sebészet, Budapest, 1908, 34.

SCHOENBAUER, L. Tuberkulose der Oberflaechlich n Lymphdruesen, der Sehnenscheiden und Schleimbeu l. Wien. klin. Wchnschr., 1926, xxxix, 1–12 (suppl. no. 3 .

SCHUCHARDT, K. Ueber die Reiskoeperbildung in Sehn - scheiden und Gelenken. Arch. f. path. Anat., 1888, cx , 186.

Idem. Tuberkulose und Syphilis der Sehnenscheid . Arch. f. path. Anat., 1894, cxxv, 394.

SKILLERN, P. G., Jr. Tenosynovitis of palmar bursa, t berculous. Internat. Clin., 1913, 23. s., iv, 242.

SMITH, A. D. The pathology of joint tuberculosis in s earlier stages. Arch. Surg., 1926, xii, 740–759.

SMITH, M. K. Tuberculosis of tendon sheath of ind x finger. Ann. Surg., 1927, lxxxvi, 149.

STABB, E. C. Tuberculosis of tendon sheath. Brit. M. J., 1891, i, 804.

STERN, E. Ueber die Aetiologie und Lokalisation der Sehnenscheidentuberkulose. Freiburg i. B., 1903.

VON TEMPSKY, A. Inoculation tuberculosis of tendon sheaths as occupational disease of butchers. Beitr. z. klin. Chir., 1931, cliv, 187–190; Zentralbl. f. Chir., 1930, lvii, 1993.

WATSON. Multiple tenosynovitis. Clin. J., 1912, xli, 83.

WESTPHAL, J. Ueber Sehnenscheidentuberkulose. Kiel, 1892.

WETTERER, J. Die Strahlenbehandlung der Tuberkulose. Strahlentherapie, 1920, xi, 386.

WILLMES, P. Histoligische Untersuchungen ueber Sehnenscheidenhygroma. Inaugural Dissertation, Berlin, 1904.

ZIEGLER, E. Fibrinous inflammation of the serous membrane. Beitr. z. path. Anat., 1897, xxi, 227–242.

ZOEPPRITZ, B. R. Ueber die Resultate der Exstirpation des tuberkuloesen Sehnenscheidenhygroms der Hand. Tuebingen, 1903; Beitr. z. klin. Chir., 1903, xxxix, 654–665.

THE TYPE AND GRADE OF GASTRIC CARCINOMA IN RELATION TO OPERABILITY AND PROGNOSIS

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IN considering the therapy of any serious disease, the cause of which is undetermined, it is essential to recognize all factors having to do with the life history of the lesion. Certainly this applies to cancer of the stomach, which ranks first in malignancy in regional classification. In the government reports from England and Wales and from the United States more than one third of the deaths due to malignancy are reported as cancer of the stomach.

The therapy of this disease is relatively young. It was in 1881 that Billroth first successfully resected the pylorus in an attempt to remove a cancer. In the intervening 50 years pessimism has constantly pervaded the profession, and is consequently inherent in the lay mind. There are many reasons for this, the primary one being the risk of the major procedure in any honest attempt to remove the disease, and the low percentage of freedom from recurrence following surgery. But other factors contribute to the gloomy prognosis offered the victims of this disease. Foremost is the usual failure of any other form of therapy in proved cases. Radium and X-ray therapy except in rare cases have not produced the arrest of the disease or even the palliative delay in distressing symptoms that can be had by applying these measures to cancer of other organs or structures.

The mimicry, in its early symptomatology, of so many benign gastro-intestinal diseases and its early symptoms of mild constitutional disturbances common to so many system disorders, insidiously hides the lesion in its early development and robs the victim of that essential time for surgical interference when the disease is confined to the walls of the stomach.

What is the result? The disease in its early form is suspected in only a small percentage of the cases even by the alert and intelligent practitioner, for he is the only one who sees the patients early. In the majority of cases when the lesion is recognized only in its maturity and is corroborated by the most efficient means at our command, namely the fluoroscope and barium meal, the pessimistic physician advises operation; the equally, if not more pessimistic surgeon explores and finds an irremovable growth; the pathologist later exhibits the lesion and demonstrates the disseminated metastases. A clinic or hospital without a long established and well organized follow-up system will undoubtedly regard the subject of gastric cancer as hopeless. To combat this impression a periodic exhibit of all 5 year arrests after resection for carcinoma of the stomach in this clinic has been shown at the clinical-pathological staff conference.

At best the operative mortality and the 10 year results are about equal in percentages—too high in the former, too low in the latter. Statistics are often both boring and misleading, but they are instructive, if reported from reliable sources in large enough series to warrant deductions. Table I containing the statistics of clinics in several countries is of interest.

Why do statistics vary so greatly in mortality rate and in interval results? The answer to the former lies in the skill and team work of the individual operator, the selection of cases, and the pre-operative and postoperative care of the patients. Statistics stress the importance of limiting gastric resections to individual surgeons of mature experience and demonstrated skill, with permanent assistants and a well thought out program. Nowhere is this better demonstrated than in the Mayo Clinic, where these major procedures have been done by a few experienced surgeons with carefully trained assistants in an astonishingly large number of patients.

The variation in late results has to be explained, however, on different grounds. Why, after recovery from the ordeal of resection, do some patients live 10 years, while the ma-

TABLE I.—RESULTS FOLLOWING RESECTION

Comparative statistics from various clinics regarding the percentages of 5 and 10 year arrests of the disease after resection. In some of these the percentages are computed from the entire number of resected cases. In others only the cases surviving operation are included. The latter group are marked by (s).

Year	Clinic	Resections	Percentage 5 year arrests	Percentage 10 year arrests
1924	Finsterer	83 (s)	31.3	
1925	Anschutz	91	22.0	
		43		21.0
1926	Hartman	100	19.0 (5–21 yrs.)	
1927	Persson	203 (s)	14.5	8.0 (6½–21 years)
1929	Walton	62	6.4	
1932	Presbyterian Hospital (Chicago)	40 (s)	20.0	
1933	Johns Hopkins Hospital	41 (s)	24.4	
1933	Presbyterian Hospital (New York City)	40 (s)	25.0	
		22 (s)		31.8
1931	Mayo Clinic (Balfour)	640 (s)		20.0
1919	Mayo Clinic (Mayo, C. H.)	234 (s)	25.0	

jority die of recurrence within a period of 3 years or less? In an attempt to answer this question 95 gastric resections for malignancy of the stomach (including 2 of sarcoma) performed at the Presbyterian Hospital over a period of 24 years have been analyzed and compared with similar groups reported from other clinics. All but 2 of the surviving 63 cases have been followed for periods of 2 months to 18 years. This study has been aided by the constant co-operation and interest of Dr. Arthur Purdy Stout, surgical pathologist, and Dr. F. B. St. John, attending surgeon, both having been interested in this subject and having reported on previous groups of gastric cancer. Dr. Stout's textbook *Human Cancer* and Dr. St. John's review of the earlier series have been frequently consulted. This discussion is based primarily upon the types and grades of malignancy in relation to operability and prognosis.

TYPES

Carcinoma of the stomach differs from carcinoma of other parts of the gastro-intestinal tract in that the majority of the cancers are less well differentiated and are therefore more malignant. This may be due to the greater variety of type and function of the epithelial cells seen in the mucosa. The literature of the subject is confused by numerous terms used in an attempt to classify these carcinomata. Especially unfortunate are such terms as carcinoma simplex, scirrhus or medullary carcinoma, or linitis plastica. No two pathologists will agree as to the exact significance of these names. The majority of such classifications have been made on the basis of the morphology of the cells and on the microscopic sections, rather than on the life history of the gross lesions.

As one sees these carcinomata under the fluoroscope, at the operating table, and after resection, in the fresh and in the fixed specimens, it is obviously clear that the growths fall into three types: (See Table II).

1. Those that form vegetative, or fungating masses with a tendency to grow more into the lumen of the stomach than to infiltrate the coats or undergo ulceration.

2. Those that grow both into the lumen and into the wall of the stomach, with marked ulceration.

3. Those that grow into and infiltrate the coats of the stomach, rather than into the lumen, and have less tendency to ulcerate.

All these types both grow toward the lumen and invade the coats of the stomach, but some, the more benign and less rapidly growing, tend to fungate, while others tend to ulcerate as growth progresses; and others, the most malignant, tend to infiltrate rather than form masses or to ulcerate.

Table II shows the relative frequency of these types and the locations in which they are commonly found. Unfortunately it is not the fungating type which is the most common of these.

The vegetative, or large fungating tumors, in this series occurred most frequently in the pars media; the ulcerating tumors were found in all parts, but most commonly in the antrum; the infiltrating type, which includes the scirrhus, the carcinoma developing on an ulcer and linitis plastica, were most frequently found in the antrum and pylorus.

TABLE II.—DISTRIBUTION OF GROSS TYPES ACCORDING TO LOCATION

In this table the gross types are distributed among the various locations. It will be noted that by far the largest percentage of fungating tumors are located in the pars media and the antrum. The true ulcerating and infiltrating growths are about equally distributed between the pylorus and antrum. The vertical and horizontal totals show the distribution of all cases among the types and locations respectively.

Location	Fungating carcinoma	Ulcerating carcinoma	Infiltrating carcinoma	Total
Pars media	12	2	5	19
Antrum	10	23	32	65
Pylorus	0	3	8	11
Total	22	28	45	95

TABLE III.—DISTRIBUTION OF GROSS TYPES ACCORDING TO GRADES

The gross types are here distributed among the four grades of malignancy. It will be seen that ulcerating carcinomata are divided between all four grades, predominating in II, III and IV. Fungating tumors are mainly in grades II and III while all of the infiltrating tumors were either grade III or IV. The horizontal totals show the prevalence of the various grades.

Grades	Fungating carcinoma	Ulcerating carcinoma	Infiltrating carcinoma	Total
I	2	1	0	3
II	7	7	0	14
III	10	11	15	36
IV	3	9	30	42
Total	22	28	45	95

GRADING

The possibility of grading the malignancy of carcinomata as seen in the stomach has been stimulated by follow-up studies. By comparing the microscopic sections of the several types of cancer with the late results, fairly definite data can be obtained for grading malignancy. Since Broders' work at the Mayo Clinic on grading the epitheliomata of the lip first appeared in 1920, increasing interest has been shown in this subject. Martzloff has studied the grade of malignancy in carcinoma of the cervix uteri, and Greenough has done the same in malignancy of breast cancer. MacCarty has published his criteria in the grading of carcinoma of stomach and rectum, but in regard to the former, the authors have been unable to agree with his conception of relative malignancy.

The grading of malignant tumors is at best only relative, and involves to a certain extent a personal factor, inasmuch as it is not based upon chemical analysis or mathematical formulæ. But even though relative, it can be of real value in its relation to the gross types of cancer and to the prognosis of the patient operated upon.

The greatest effort has been concentrated on the correlation of the gross types and microscopic sections with the clinical history and follow-up results of the cases. It should be stressed that the grades used are entirely arbitrary. The criteria set forth here are offered not to determine the exact percentage of four grades, but as a means of correlating the clinical, gross, and microscopic characteristics. They are by no means original, but out of many others considered as signs of malignancy, they have seemed to be most significant of carcinoma of the stomach. The following criteria of microscopic pathology have been used in determining the grade of malignancy:

1. The degree of cell differentiation. Marked deviation from the normal glandular arrangement of the cells indicates a more malignant grade.

2. Cellular activity. This is indicated by the variation in shape and size of the cells and their nuclei, and the variation in cell types in the same tumor. These are considered even more significant than the number of mitoses and the chromatin content of the nuclei.

3. The invasiveness of the tumor cells, whatever their arrangement or differentiation. The invasion is to be noted in the lymphatic channels and about the nerves and vessels, as well as in the muscles and the serosa.

4. The lack of cohesiveness in the tumor cells, whatever their arrangement. Delbet has called attention to this in breast cancer. This is considered equally indicative of extreme malignancy in gastric cancer.

5. Metastases in the lymph nodes. This is a sign of malignancy, but not necessarily an indication of the grade of malignancy. Absence of lymph node involvement greatly enhances the prognosis.

As in the epitheliomata graded by Broders, it is fairly easy to divide the gastric cancers

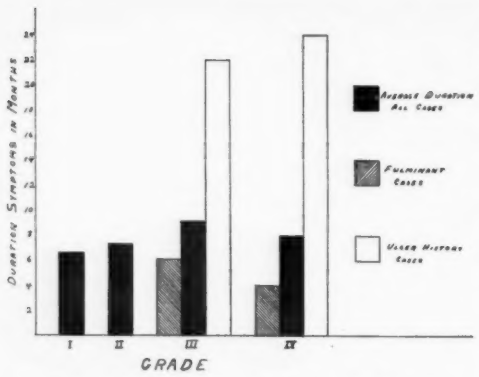

Table IV. This chart represents graphically the average duration of symptoms in all grades. Taken as a whole this varies little in the different grades. If, however, from grades III and IV those cases with histories typical of gastric ulcer are segregated it is seen that the symptom durations fall into two clear cut groups, the fulminant symptoms of 6 months or less and the insidious ulcer symptoms of 12 or more months' duration.

into the relatively benign and the very malignant grades. Perhaps it would be wiser to do this than attempt to separate them into four grades. In this scale of malignancy grade I merges into grade II, II into III and III into IV, and there are no hard and fast dividing lines. Nevertheless it may be interesting to note the fact that both the authors, in studying the sections independently and recording their individual grading against the numbers of the slides, found the grades to coincide in about 95 per cent of the cases. (Table III.)

There is a fairly definite relation between two of the types and the grades. That is, the vegetative or fungating type most often shows the less malignant grades I and II. The infiltrating type most frequently fall in grade IV. The ulcerating type may, however, prove on microscopic examination to be either grade II, III, or IV.

It will be noted that the percentage of carcinomata developing on chronic ulcers has not been discussed. This question has been argued for almost 100 years since Cruveilhier first distinguished chronic gastric ulcer from carcinoma and intimated a causal relation between the two. The opinions of both surgeons and pathologists have varied so extremely on this etiological relationship that an utter lack of uniformity in the interpretation of observed facts is evident. Agreeing with the more recent writers on the subject, it is felt in this clinic that the incidence of carcinoma found associated with true chronic ulcer in resected stomachs, where microscopic sections of the entire lesion are examined, is low. In this group of 95 resections there were 6 cases. But the authors emphatically agree with Cabot and Adie, with Bueerman, and with Scott in placing emphasis, not upon the percentage of carcinomata developing on an ulcer base, but upon the fact that the two are so often indistinguishable in the patient. It is desired furthermore to emphasize the fact that this study has demonstrated that the carcinomata thought to have developed on an ulcer belong to the infiltrating type, and are almost invariably grade IV in malignancy. In this group no patients have remained well longer than 39 months.

This has been noted in other series. Thus Bueerman, in a study of 1,142 gastric cancers from the Mayo Clinic, found that carcinoma on ulcer occurred in only 0.52 per cent of the ulcerating carcinomata studied. He also states that upon the bases of Broders' classification, carcinomatous gastric ulcers have a relatively high grade of malignancy, 78.9 per cent occurring in grades III and IV.

OPERABILITY

The pre-operative determination of the type of tumor and grade of malignancy is a more difficult problem. This has to do with the question of operability. Our studies have brought out certain data which may be of use in this determination. Because of the inaccuracies in the case histories, inherent in the varying intelligence of the patients, in the varying reaction of the patients to discomfort and their inconstant recognition of constitutional disturbances, the duration of the disease is difficult to estimate. When the carcinoma is located in pain sensitive areas, as in the lesser curvature, or where ulceration produces bleeding, the patient is more apt to seek medical advice early. Pain and bleeding are compelling symptoms, and they would seem to be more often seen in the ulcerating

carcinomata found in the antrum on the lesser curvature.

The duration and type of symptoms bear an interesting relationship to the grade of gastric cancer. Summarizing the average duration of symptoms in all grades it is found that in grades I and II the onset of symptoms commonly begins 7 or 8 months before the patient seeks advice from a physician. As shown graphically in Table IV, grades III and IV give symptoms of slightly longer duration, namely 8 or 9 months. If the latter two groups are classified and those giving typical ulcer histories segregated, it is found that the average duration of these cases is over 20 months, while the duration of the remaining majority averages 6 months for grade III and 4 months for grade IV. In other words, patients who give a rapid, fulminating history of carcinoma are most apt to harbor a growth of relatively greater malignancy. Those which give a history suggestive of a gastric ulcer lasting over several months which progresses steadily and fails to abate after conservative treatment are likewise apt to fall in grades III and IV. On the other hand, the tumors giving clinical manifestations of no great severity which develop slowly over several months are in the majority of instances grades I and II. (Table IV.)

Differentiation of types is more difficult from the physical findings. The large fungating tumors are, however, more apt to be felt by the physician than the other types and, with the large ulcerating carcinomata, are more often recognized by the radiologist as filling defects, and less apt to be confused with gastric ulcer.

Gastric analysis frequently shows an absence of free hydrochloric acid in carcinoma, but this finding is not always constant. These studies have brought out some interesting points in the relation of acidity to type, grading, and result. The percentage of achlorhydrias is greatest in the fungating type, least in the carcinoma-on-ulcer type, greatest with tumors located in pars media, least in pylorus. The percentage of achlorhydrias is inversely proportional to the ascending grade of malignancy, and of the 14 cases presumably well in which the acidity was determined, hydrochloric acid was absent in 11. These findings emphasize the significance of acid determinations but in so small a group of cases it is impossible to foretell their importance. (Table V.) Whether this would hold true in a large series remains to be seen, but it is worth considering in cases showing a palpable mass with a filling defect in the X-ray films.

TABLE V.—COMPARISON OF GASTRIC ACIDITY WITH RESULT

In a comparison of gastric acidity with the result of resection as shown in this table it is interesting to note that presumable cures are about four times as frequent in cases having no free acid. In the group dying from recurrent cancer, free acid was present in the gastric contents of the majority.

Result	Free HCl present	Free HCl absent	No analysis	Total
Presumably well	3	11	7	21
Dead following operation	7	14	11	32
Dead from recurrence	14	12	16	42
Total	24	37	34	95

A case showing a palpable tumor with filling defect in the pars media without great loss of weight and strength, without a severe anæmia, and with achlorhydria, would be considered as a probable fungating type of grade I or II. On the other hand a case showing rapid loss of weight and strength, an anæmia, with free hydrochloric acid present and X-ray findings showing an infiltrated wall or suggesting an old ulcer in the region of the pylorus, would be considered as an infiltrating type of grade III or IV. The finding of a tumor mass that is movable, without signs of fluid or a nodular liver, in an individual that is not cachectic is a favorable sign, and promises well for surgery. This is especially true if the X-ray shows a filling defect in the pars media.

Golden, summarizing the roentgenological criteria of gastric malignancy as used at the Presbyterian Hospital, has emphasized the difficulty in the detection of an "early carcinoma" or one which is arbitrarily assumed to be 1 centimeter or less in diameter. He feels that such a lesion might be detected in the media by (1) interruption of the peristaltic waves on the lesser curvature, (2) obliteration of mucosal folds (an observation which is hard to make with certainty), or (3) a crater

TABLE VI.—DISTRIBUTION OF GRADES ACCORDING TO METASTASES

In this table the grades are compared with the presence or absence of lymph node involvement. It is easily appreciated that the vast majority of cases with metastases fall into grades III and IV while those in which the cancer was strictly limited to the stomach walls were about equally distributed between grades II, III, and IV.

Grade	Glands involved	Glands not involved	Total
I	0	3	3
II	2	12	14
III	22	14	36
IV	29	13	42
Total	53	42	95

shadow if the growth happens to be ulcerated. If this lesion, proved roentgenographically, happened to lie on the greater curvature, it could be interpreted with great certainty as carcinoma. If on the lesser curvature, it could only be differentiated from a peptic ulcer by a period of observation during which time it was given an opportunity to heal under palliative treatment. In the antrum, the normal peristaltic wave as such gives way to a systolic antral contraction of such magnitude that it might not be obliterated by even an extensive infiltrating carcinoma. The presence of such a growth might, however, be betrayed by spasm or slight rigidity of the antral wall.

It is easy to confuse the X-ray picture of early carcinoma of the pylorus with that of hypertrophy and spasm of the pyloric muscle. This differentiation cannot be made with certainty without repeated re-examination and even then, the constant finding of an elongated, pyloric channel cannot always be taken as infallible proof of a gastric carcinoma.

The interpretation of the operative findings should further enable the surgeon to foretell the prognosis. Free fluid with nodules in the peritoneum of the omenta or of the pelvis, or nodules in the liver, are of course evidence of widespread metastases and contra-indicate resection unless the nodule in the liver is single and the patient is in excellent condition. The presence of nodules in the serosa of stomach, or a beaded and granular serosa in the region of the tumor, is evidence of peritoneal invasion and probably lymphatic involvement, but does not contra-indicate resection; nor

TABLE VII.—INFLUENCE OF METASTASES UPON RESULT

The percentage of metastases in the resected cases are shown in this table and with it the comparative results in cases with and without metastases at the time of operation.

Result	With metastases	Without metastases
Living less than 5 years (maximum 29 months).	11	11
Living more than 5 years	0	9
Dead following operation	21	11
Dead from recurrence of growth	21	11
Total	53 (55.8%)	42 (44.2%)

does the adherence of the tumor mass to adjacent organs such as the colon, liver, or pancreas, for this may be inflammatory. The colon was resected in 3 cases of this series because of the close adherence to the tumor. All 3 recovered, 1 has been living 12 years, another 4 years. Neither of these showed microscopical involvement of the colon. The third died of recurrence.

The finding of a nodule in the duodenum does not necessarily mean tumor tissue. Not infrequently have such nodules, thought at first to be carcinomatous, proved to be accessory pancreatic tissue or some other type of benign tumor. The frozen section diagnosis of such tissue is very difficult, as illustrated in the case reported by Scott. The significance of enlarged, firm lymph nodes along the curvatures, around the head of the pancreas and in the gastrohepatic omentum is easily misinterpreted, for such lymph nodes may be inflammatory, especially in the ulcerating type of lesion. Bothe observes that the size of the nodes bears no definite relation to their involvement, nor does the size of the growth have any relation to the number of nodes involved. Furthermore, the presence of metastases in lymph nodes does not necessarily indicate the grade of malignancy. Highly malignant carcinomata usually metastasize early and may reproduce in the node more than one histological type. Relatively benign tumors if allowed sufficient time will also metastasize but here the cellular structure of the metastasis is almost invariably like that of the parent tumor. (Table VI.)

The presence of enlarged nodes should therefore not contra-indicate resection. Their presence is an added reason for removing as much of the attached omenta as possible in a wide resection. Not until all the excised

TABLE VIII.—INFLUENCE OF GRADE UPON RESULT

The influence of grade upon result is here depicted. If the percentages are computed it is strikingly apparent that the presumably well cases are inversely proportional to the ascending grade of malignancy while the reverse is true in those cases dying of recurrence.

Grade	Presumably well	Post-operative deaths	Dead from recurrence	Total
I	3	0	0	3
II	7	5	2	14
III	9	12	15	36
IV	2	15	25	42
Total	21	32	42	95

lymph nodes have been carefully sectioned can the extent of lymph node involvement be evaluated and the prognosis determined. The finding of one carcinomatous lymph node adjacent to the tumor, with the others free, indicates a better prognosis than when all the regional nodes are involved. Nevertheless the gravity attending lymph node involvement must again be emphasized. In this series, 56 per cent of the resected carcinomata had extended to the lymph glands. None of this group of cases has lived more than 29 months after operation. On the other hand, none of the patients who have lived 5 years or more had metastases to the nodes. (Table VII.)

RESULTS

In some of the foregoing tables, mention has been made of the results obtained in this group of 95 cases by gastric resection. It is perhaps relevant at this point to explain the classification into result groups. Table VIII compares results with grades. It will be noticed that results have been grouped under three headings. Under "Presumably well" is included all cases living and well after resection in which no lymph gland involvement was noted. These number 21. Of these, 7 have passed the 10 year mark and 9 have lived longer than 5 years. The remaining 12 have survived from 8 months to 4 years without showing signs of a recurring growth. Two of these died 18 months and 3 years after operation as a result of unrelated disease.

All patients dying in the hospital as a result of the operative procedure and its various

TABLE IX.—RESULTS OF TREATMENT

Results of treatment in all of the resected cases. It is of interest to note that of the 26 living cases only 7 had metastatic involvement of the nodes. Four of these at present show signs of recurring cancer. The 2 patients who died of unrelated causes should be classed as presumably well since at operation no metastases were found and no manifestation of malignancy was apparent before death.

Living			
Well, 10 years or more			7
Well, 5 years or more			2
Living from 8 to 48 months without metastases and without signs of recurrence			10
Living from 2 weeks to 29 months with nodes involved but without signs of recurrence			3
Living, nodes involved but showing signs of recurrence			4
Total			26
Dead			
From recurrence of the tumor			35
Following operation:			
Shock	11		
Hæmorrhage	2		
Infection	5		
Pneumonia	11		
Other causes	3		
		32	
Died of unrelated causes without signs of recurrence at 18 and 36 months respectively		2	
Total			69
Total			95

complications have been counted as post-operative deaths. Of the 42 recurrent cases, 35 patients have died from 6 months to 5 years after operation. Of the remaining cases, 4 patients though still living, are showing signs and symptoms of a recurrence. The last 3 are symptomfree at intervals of 2 weeks, 3 weeks, 5 weeks, and 29 months, respectively, after operation. It has seemed justified therefore to include these cases in the recurrent group since they had metastasized to lymph nodes and experience has shown the prognosis in such cases to be extremely poor.

To aid in illustrating these results Table IX was made to show in detail the distribution of the 95 cases among the result groups.

CASE REPORTS

The following case reports illustrate tumors typical of the three gross types and their respective grades of malignancy.

CASE 1. *Fungating type. Unit Hist. No. 42856. Clinical features.* G. A., a white male, aged 50 years, was admitted to the hospital on August 5, 1919, complaining of "gas in the stomach" for 15 months. This was sometimes accompanied by a dull ache in the epigastrium about 1 hour after meals and usually relieved by eating and soda. For 10 months he had been troubled by sour eructations and distention. There had been some loss of strength and during the 3 months previous to admission he had lost 10 pounds.

Physical examination revealed a poorly nourished man who appeared to be chronically ill. The abdomen was scaphoid and on palpation, a slightly tender, movable mass was felt just to the left of the umbilicus. There was also a visible protuberance in the right upper quadrant which appeared to move with respiration. The condition was diagnosed carcinoma of the stomach and operation advised. X-rays showed a large filling defect along the lesser curvature in the pars media (Fig. 1).

Operation. The abdomen was opened on the day following admission and the operator immediately felt a large, hard, freely movable mass in the greater curvature. Since it was nowhere attached, resection was thought advisable, and carried out by the Billroth II procedure. No enlarged glands were felt and no metastases could be made out in the liver.

The postoperative course was uneventful and the patient left the hospital in good condition.

Gross pathology. The specimen (S. Path. No. 23185) consisted of a large portion of the stomach. The viscus was opened and a large cauliflower shaped growth (Fig. 2) was seen occupying the posterior wall and lesser curvature of the pars media. It projected well into the stomach cavity. It was hard but appeared to be well circumscribed. No enlarged nodes were found attached to the specimen.

Microscopic pathology. The growth was composed of hyperplastic epithelial cells growing in an alveolar manner. The tumor cells had invaded the muscle wall but had not involved the serosa. They were well differentiated, cohesive, and had not invaded the blood vessels or lymphatics (Fig. 3).

There were no metastases.

Diagnosis: Carcinoma of stomach, Grade I—fungating type.

The patient has remained well for 14 years.

CASE 2. *Ulcerating type.* Unit Hist. No. 350803.

Clinical features. F. B., a white male, aged 48 years, entered the hospital August 18, 1932. The onset of his symptoms dated back one year previously when he first noticed gaseous eructation, indigestion, and occasional vomiting. These he dated from a dietary indiscretion. All symptoms gradually became worse and during the 3 months previous to admission he had suffered from diarrhœa. During this time he had lost 10 pounds and felt weaker than usual and generally below par. Vomiting had increased in frequency.

Physical examination revealed a well developed, white man with a marked secondary anæmia. There was felt in the abdomen in the region of the pylorus, a mass the size of a lemon which was non-tender and movable. It did not appear to move with respiration.

X-rays after a barium meal showed a characteristic irregular filling defect surrounding the antrum of the stomach (Fig. 4). There was also a 20 per cent 4 hour retention of the barium meal. The red cell count was 3,870,000 and the hæmoglobin 58 per cent. Gastric expression showed no free hydrochloric acid in any specimen. Carcinoma of the stomach was diagnosed and operation advised.

Operation. Partial gastrectomy. On opening the abdomen the operator felt a large, hard growth surrounding the stomach in the antrum. It was not attached to any surrounding structures and resection was thought feasible. This was carried out by the Pólya method with a posterior gastro-enterostomy and entero-enterostomy.

The post-operative course was uneventful except for a partial disruption of the abdominal wound. This healed rapidly and the patient was discharged from the hospital improved.

Gross pathology. The specimen (S. Path. No. 49455) consisted of the distal half of the stomach. When it was opened a large, friable growth was found encircling the antrum and partially constricting the lumen. It extended upward along the lesser curvature 5 centimeters and along the greater for a distance of 8 centimeters. The surface of the tumor was markedly ulcerated. The stomach wall was apparently not infiltrated beyond the visible limits of the tumor. No enlarged lymph nodes were felt (Fig. 5).

Microscopic pathology. The growth was composed of moderately well differentiated epithelial cells growing in a glandular form. There were large deposits of mucus and slight secondary degeneration of the epithelium. The growth had invaded the entire wall including the serosa, but the blood and lymph vessels were not involved (Fig. 6).

There were no metastases.

Diagnosis: Carcinoma of the stomach, Grade II—ulcerating type.

The patient is symptom free at present one year after operation.

CASE 3. *Infiltrating type.* Unit Hist. No. 332186.

Clinical features. H. S., a white female, aged 66 years, came to the hospital on March 7, 1932, with the primary complaint of indigestion, epigastric fullness and nausea. These symptoms had been present for 4 months and had gradually increased in severity. There had been no previous history of gastro-intestinal disorders. The last 3 weeks of the illness had been characterized by anorexia, loss of strength, and occasional vomiting. The patient had lost a total of 30 pounds in 6 months.

On physical examination the patient was seen to be a cachectic old lady with marked emaciation. In the midepigastrium could be felt a tender, slightly movable mass about 7 centimeters in diameter. This shifted with respiration.

X-rays (Fig. 7) showed a filling defect involving the entire antrum and extending up onto the walls of the pars media. This apparently encircled the lumen and partially constricted it. The red cell count was 6,650,000 and the hæmoglobin 84 per cent. Acid determination on specimen of vomitus yielded no free hydrochloric acid.

The lesion was diagnosed carcinoma and operation performed.

Operation. The abdomen was opened and the operator could immediately feel a rather large and extensive mass occupying the distal half of the

Fig. 1. Case 1 (S. P. 23185). Roentgenogram showing huge filling defect primarily on the lesser curvature but also encroaching upon the lumen from the greater curvature and behind. This is typical of a fungating carcinoma.

Fig. 2. Case 1 (S. P. 23185). Photograph of gross specimen. This shows a huge fungating tumor arising from the posterior wall and lesser curvature and almost filling the resected portion of stomach. Its outlines are, however, clearly demarcated.

stomach. It was not grossly adherent to surrounding structures and successful removal was thought possible. Accordingly a subtotal gastrectomy was done after the Pólya-Balfour method and an enteroenterostomy.

Gross pathology (S. Path. No. 47745). The distal end of the stomach was occupied by a large, infiltrating tumor mass which extended from the pylorus upward for a distance of 12 centimeters on all sides. The lumen was almost occluded. The surface was indurated but not markedly ulcerated. The growth had invaded the entire wall and involved the serosa. Enlarged glands were felt along the greater and lesser curvatures (Fig. 8).

Microscopic pathology (Fig. 9). The tumor was composed largely of very poorly differentiated cells arising from the tips of the crypts and invading the entire wall in a non-cohesive manner. There was moderate mucous secretion but very little attempt at gland formation. The glands were involved by tumor cells of the same type. The size and shape of the cells varied greatly and the general appearance was that of a very malignant tumor.

Metastases were noted in the superior and inferior gastric glands.

Diagnosis. Carcinoma of stomach, grade IV—infiltrating type.

The patient died 7 weeks after operation from a recurrence of the tumor.

SUMMARY AND CONCLUSIONS

This leads to the conclusions drawn from the study. It is evident that the division of carcinomata into three gross types and into four grades of malignancy is an inexact classification, but when taken with certain pre-

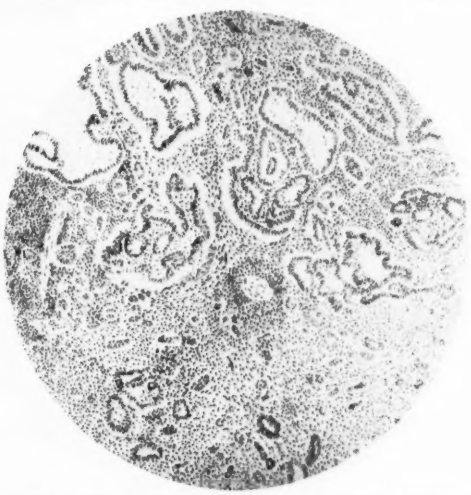

Fig. 3. Case 1 (S. P. 23185). Low power photomicrograph. The cells are well differentiated, glandular, cohesive, and do not invade beyond the submucosa. There is a moderate cellular infiltration.

Fig. 4. Case 2 (S. P. 49455). Roentgenogram showing an annular filling defect of the antrum. The outlines are very irregular indicating an ulcerated tumor. Moderate constriction has produced some dilatation of the viscus.

operative and operative findings these pathological criteria may be helpful to the surgeon in determining the operability and the operative procedure, and to both the surgeon and pathologist in estimating the prognosis. Only when the surgeon and pathologist collaborate in the study and become familiar with the material as it accumulates, will it aid them. The writers would urge that these cases be studied clinically and pathologically by a combined group of physician, surgeon, roentgenologist, and pathologist, in an effort to make the diagnosis at the earliest possible stage of the disease. Such a combined clinic would rapidly repay the time and effort put into it, by the durable satisfaction of the improved results and by the increasing number of patients that will be referred or who voluntarily come to such a clinic, the reputation of which will rapidly spread. In such a clinic both benign and malignant lesions of the stomach should be studied by the group, and all follow-up visits be seen. It is the return visits of patients, bringing with them their results, good or bad, whatever the therapy applied, that make the members of the team speak the same language and agree upon definite therapeutic policies.

For such a combined gastroduodenal clinic the authors feel that a modification of the plan first suggested by Scott would be highly advantageous. This embodies a clinical classification of gastric ulcers whereby the possibly malignant cases are definitely segregated and given the closest of attention. This classification contains four groups as follows:

I—Ulcer suspect.

II—Ulcer verified.

III—Ulcer verified, carcinoma suspect.

IV—Ulcer verified, carcinoma verified.

Group 1 includes a large number of cases whose clinical story suggests ulcer but in which there is no confirmatory evidence. In a large majority of these the symptoms do not permit the localization of the lesion, hence they must of necessity be classed loosely as "peptic ulcers." Many no doubt are due to the ulcer-mimicking symptoms of other upper abdominal pathology. Hence, as Moynihan has pointed out, it is far better to base any critical study of gastric ulcer on cases in which the diagnosis has been proved by operation or X-ray. This group is therefore of use primarily in differential diagnosis and their treatment should be limited to palliative measures.

Group II contains only those cases in which the clinical impression of gastric ulcer has been confirmed by roentgenological studies. Upon these patients conservative treatment is concentrated, ambulatory if possible, hospitalization if necessary. They are to be watched closely for definite signs of improvement or exacerbation. Those which respond favorably to conservative treatment are maintained in this group although they should be observed closely for indications of a recurrence through the medium of the follow-up clinic. This observation cannot be overemphasized for it is not at all unusual for an ulcerating carcinoma to show signs of improvement after hospitalization and medication. If symptoms are not markedly abated or if they increase, the patient must then be passed on to group three.

Fig. 5. Case 2 (S. P. 49455). Photograph of gross specimen. This shows a huge ulcerating tumor surrounding and constricting the antrum and pylorus. The growth has not extended beyond the pylorus and the proximal border is well marked.

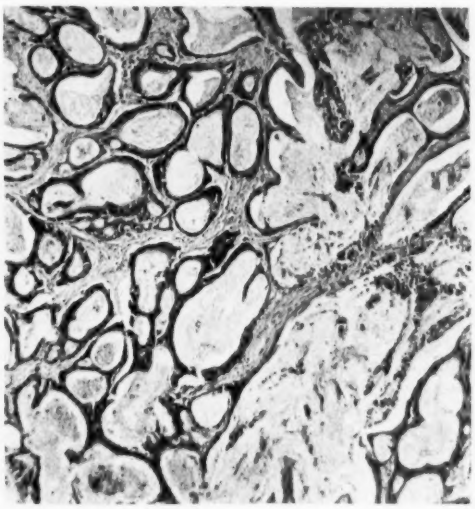

Fig. 6. Case 2 (S. P. 49455). Photomicrograph. The tumor is composed of glandular epithelium which is cohesive, well differentiated, and actively secreting mucin. There is evidence of degeneration in the epithelial lining of the mucinous cysts.

In group III, ulcer is verified, cancer is suspected. Further treatment varies with the physician or surgeon but this is the stage at which exploration is of most value and resection should be done if there is to be the hope of removing the early cancerous lesion before it has disseminated. No doubt many benign ulcers are resected in this stage but in view of the low operative mortality attending gastric resection for benign ulcer and the possibilities for removal of a potential cancer, one can hardly doubt the efficacy of the procedure.

When the lesion has been proved carcinomatous beyond reasonable doubt, the patient passes into group IV. This differentiation can in rare cases be made by the roentgenologist who notes a rapid increase in the size of the lesion with an appreciable filling defect. More frequently the operator who explores finds evidence of infiltration and invasion, sometimes with lymph node involvement which bespeaks the presence of malignancy. But most often it is not until the lesion is examined beneath the microscope that the cancerous nature is recognized and the justification par excellence for resection is established.

We have discussed the difficulties of early diagnosis for carcinoma of the stomach in general. The delay in diagnosis in the fungating type is not so serious as in the other types. Both the fungating and ulcerating types coming to resection are diagnosed by X-ray study in well over 90 per cent. But there are two groups of cases that are most difficult to diagnose in the early stage. One is the infiltrating type of carcinoma, appearing in the patient with no past history of digestive disturbances, with the first symptoms those of constitutional disorder—loss of energy, appetite, and weight, and fatigability, or with epigastric discomfort but with negative barium X-ray studies. This insidious lesion almost always remains confined to the gastric wall, interfering so little with normal gastric function that when constitutional symptoms first arise the stomach is rarely suspected as the source of trouble.

The second difficult group is composed of patients giving a previous history and X-ray diagnosis of gastric ulcer, but with insidious symptoms of a change in the character of the epigastric pain and a failure of diet to control it, or in the appearance of the constitutional disturbances shown by slight loss of energy,

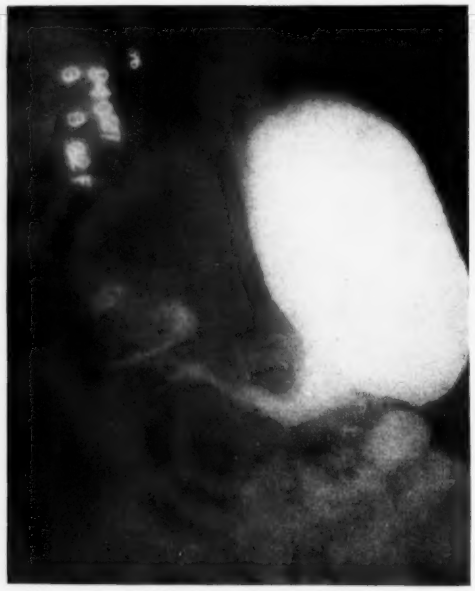

Fig. 7. Case 3 (S. P. 47745). Roentgenogram showing a constricting antral defect. Note the smooth outline of the stomach wall in contrast to the irregular shadow in Figure 4, indicating a tumor of the infiltrating type.

Fig. 8. Case 3 (S. P. 47745). Photograph of the gross specimen showing extensive invasion of the stomach wall by tumor. The viscus has been converted into a rigid tube and the surface is pebbled and granular but not ulcerated.

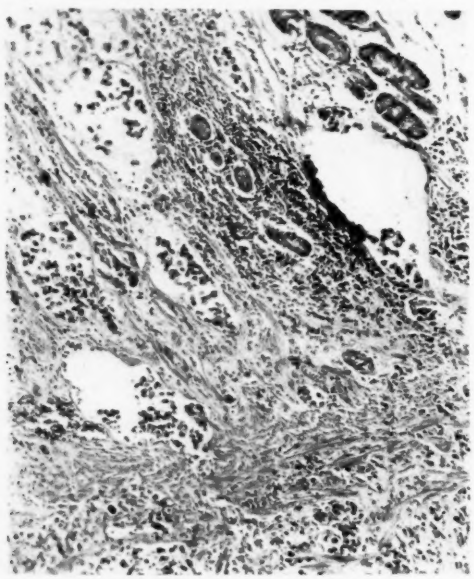

Fig. 9. Case 3 (S. P. 47745). Photomicrograph showing normal mucosa in lower right hand corner from which tumor cells are arising. Mucus is being produced. The cells are poorly differentiated, non-cohesive and invasive.

appetite, and weight. Again, this carcinoma is of the infiltrating type and of a highly malignant IV grade. If the clinician waits until the X-ray studies are undoubtedly positive for carcinoma, the growth will in all probability have extended beyond the confines of the stomach.

The criteria of Lahey and Jordon (17) for the limits of conservative treatment in these cases are well worth noting. They require that, within a period of 3 weeks, symptoms be completely relieved; that the lesion, by repeated X-ray study, must show definite decrease in size; and that blood disappear from fæces and gastric contents. Maes has well summarized this important therapeutic problem:

"The only safe plan is to regard as cancer any indigestion, with or without symptoms, which appears after middle life in a previously well person; to regard as cancer any acute digestive disturbances, in this period, which are superimposed upon chronic digestive disturbances and which do not respond to routine measures; to regard as cancer, or highly su-

picious of it, vague general symptoms of fatigue, malaise, mental indifference, insomnia etc., even though associated gastric disturbances are lacking; to continue to regard as cancer any one of these clinical syndromes until it is proved beyond the shadow of a doubt not to be cancer; and to resort without delay to exploratory laparotomy, if the diagnosis cannot be made otherwise. In malignant disease the certainty of diagnosis is frequently also the certainty of death."

Again as Arthur Curtis remarks,

"It is better to have a less accurate diagnosis and a more favorable prognosis."

Certain it is that only by operating on these infiltrating types of cancer before the tumor cells have passed beyond the stomach walls, will the victim be saved. The earlier the surgical attack, the better the prognosis.

In conclusion it is to be emphasized that only by becoming familiar with the life history of the different types of growth and grades of malignancy in carcinoma of the stomach can we arrive at an estimate of the relative operability and prognosis in this dreadful disease.

BIBLIOGRAPHY

1. Anschuetz, W. Muenchen. med. Wchnschr., 1925, lxx, 1.
2. Balfour, D. C. Surg., Gynec. & Obst., 1927, xliv, 103.
3. Idem. Surg., Gynec. & Obst., 1932, liv, 312.
4. Billroth, T. Wien. med. Wchnschr., 1881, vi, 162.
5. Bothe, F. A. Surg., Gynec. & Obst., 1927, xliv, 761.
6. Broders, A. C. J. Am. M. Ass., 1920, lxxiv, 656.
7. Bueerman, W. H. West. J. Surg., Obst. & Gynec., Nov. 1930 to Dec. 1931.
8. Burgess, A. H. Brit. M. J., 1927, i, 1.
9. Cabot, H., Adie, G. C. Ann. Surg., 1925, lxxix, 86.
10. Cruveilhier, J. Anat. Path. du Corps humain, Paris, 1829–1842.
11. Delbet, R. Bull. de l'Ass. franç. p. l'étude du cancer, 1923, xii, 69.
12. Finsterer, H. Wien. klin. Wchnschr., 1924, xxxvii, 1157, 1181.
13. Gatewood. Ann. Surg., 1932, xcvi, 588.
14. Golden, Ross. Personal communication, 1933.
15. Greenough, R. B. J. Cancer Research, 1925, ix, 453.
16. Hartman, H. Presse méd., 1926, xxxiv, 257.
17. Jordon, S. M. Surg. Clin. N. America, 1929, ix, 1411.
18. MacCarty, W. C. Ann. Surg., 1922, lxxvi, 9.
19. Maes, U. Am. J. Cancer, 1932, xvi, 815.
20. Martzloff, K. H. Bull. Johns Hopkins Hosp., 1923, xxiv, 141.
21. Persson, M. Ann. Surg., 1927, lxxxvi, 321.
22. Schwyzer, A. Ann. Surg., 1932, xcii, 540.
23. Scott, W. J. M. Surg., Gynec. & Obst., 1928, xlvi, 199.
24. St. John, F. B. Ann. Surg., 1925, lxxxi, 283.
25. Walton, A. J. Brit. M. J., 1929, i, 939.
26. Wegele, C. Muenchen med. Wchnschr., 1926, lxxiii, 819.

CANCER OF THE COLON

Notes on Its Surgical Treatment[1]

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With the exception of the small group of cases which present themselves with acute intestinal obstruction, cancers of the large bowel may be relegated, in so far as their surgical treatment is concerned, into the category of chronic ailments. This is of not inconsiderable significance in that it allows time to institute preliminary measures aimed at increasing safety factors in the extirpation of these organic lesions. Obstruction unquestionably is present in the vast majority of cases of carcinoma of the large bowel at some time during their existence, varying in degree from the chronic variety to acute stenosis.

Burgess, of Manchester, reviewed a large series of cases of acute intestinal obstruction and noted that one-third of all cases resulted from acute stenosis of the large bowel. His statistics showed, moreover, that if one excluded hernias and intussusception, and localized the lesion to the colon, there were nine chances in ten that it was a cancer. Furthermore, this type of obstruction almost invariably occurred in the left colon. The reason for the difference in occurrence of obstruction in the right and left halves of the colon is not only the type of fæcal content, and anatomical construction of the bowel wall, but also the pathological variety of growth encountered. The scirrhous carcinomata of the left colon have a tendency to encircle the bowel lumen. The cancers on the right side usually are flat, ulcerating, do not encircle the bowel, are larger in caliber, and more elastic, and the fæcal content is liquid.

In a not inconsiderable experience, I have only twice operated upon acute intestinal obstruction due to cancer of the right colon, and in both instances the growth was situated at the ileocæcal valve rather than at the juncture of the cæcum with the ascending colon which is the common location.

As a rule, obstruction is slow and progressive, and for that reason a chronic undermining of the individual's resistance, a progressive dehydration and desiccation, and intoxication take place because the cancer of the colon has been present for a period of nearly a year before the individual seeks advice. To combat such a situation, the institution of preliminary rehabilitory measures, as well as decompression of the bowel, are most advantageous. Consequently, one may divide the phases of the surgical offensive against cancer of the colon into one of preliminary preparation, operative, and convalescent periods. Of these three phases the first is by no means the least important in its influence upon hospital mortality and operability. To increase the individual's resistance, and to decompress the colon itself, is the aim of this preliminary preparatory period. One might epitomize the steps in this sequence by saying that decompression, hydration, vaccination, and rehabilitation constitute preliminary preparation.

We have found it advantageous to attempt to decompress chronically obstructed colons by the employment of mild purgation and bowel irrigation over a period of from 3 to 6 days. In the vast majority of instances, even when the obstruction is of the subacute variety, one will be rewarded with finding a clean, flat colon at operation. I take it that it is perfectly understood that no attempt to decompress an acutely obstructed colon by other than surgical methods is ever attempted. To do so is folly, and from the patient's standpoint, fatal. Chronic colonic obstruction may be well borne for a considerable period, however, and repeated efforts to relieve the bowel of its content are well worth while persisting in for a time. The warm irrigations of normal saline not only rid the bowel of its content but secondarily they reduce the infection around the growth which is an important circumstance.

Obstruction and ulceration, as Herrman has pointed out, increase enormously the permeability of the bowel wall and consequentl

[1] Read before the Chicago Surgical Society, November 3, 1933.

extravasation of infective organisms into the pericolonic tissues takes place. This is the process from which lethal peritonitis most often develops. The graded operations which permit sidetracking of the growth or irrigation of the bowel likewise assist in reducing this infection during the interval between stages.

While decompression is taking place, hydration is accomplished by blood transfusions and the ingestion of large quantities of fluids, particularly fruit juices. Within the past year I have routinely employed blood transfusions in all cases of cancer of the colon and rectum before operation, and I believe that it is decidedly advantageous. I have not been governed by the hæmoglobin index in this matter, but have felt it decidedly helpful even when the general condition of the individual seemed fairly satisfactory. A high caloric diet, low in residue is likewise employed.

The routine use of an intraperitoneal vaccine of streptococci and colon bacilli was begun by Bargen and me in 1927 and has been continued advantageously up to the present time. Theoretically, this measure should increase the resistance of the individual to infective organisms which are so uniformly present in the pericolonic tissues and about the growth itself. We reported a series of cases in which there was a large difference in the mortality rate between the group of 60 cases of carcinoma of the colon, vaccinated before operation, and a control group of unvaccinated patients operated upon by the same surgeons. Subsequently, in 1931, we reported 222 cases of carcinoma of the colon and rectum, in which the patients were vaccinated and operated upon between January 1 and October 1, 1929, and 58 cases in which operation was done during the course of these months under similar conditions, but without vaccination. In the large group, 11 deaths occurred from peritonitis, while in the small group 13 deaths occurred from peritonitis—a mortality of 4.9 per cent versus 22.4 per cent. I do not believe that vaccination accounts for the entire improvement in the hospital death rate. That it had a favorable influence, seems to me to be obvious, but to abandon all other preliminary measures, as well as careful operative selection of cases in favor of its use would, I think, be foolhardy. However, as a step in the sequence of events aimed at increasing the individual's resistance to infection, I feel that it has proved of distinct value. Certainly there are no disadvantages to its employment.

SELECTION OF CASES

The selection of cases for operation involves the exercise of mature surgical judgment if one is to extend the horizon of operability and extirpate colonic cancers with a reasonable hospital death rate and the hope of satisfactory ultimate results. While operability must be a flexible term with distinct shadings in different hands, there are three general principles which I believe are fundamental in the acceptance or rejection of a given case for radical operation, namely: first, hepatic metastasis; second, excessive local fixation to the abdominal parietes or adjacent viscera; and third, the general resistance of the host as evaluated in terms of resistance to formidable operative procedures. In the first of these factors—hepatic metastasis—there is no question of rejection for radical operations, yet in a small group of cases in which the local growth is readily removed by some type of operation without too high a mortality, I believe the resection is justifiable because of the painlessness of death from liver metastasis in contradistinction to the unhappy demise from a fixed, ulcerating, painful cancer. That this group is extremely small, cannot be denied, but occasionally I have felt it worth while to remove an obstructing cancer which is freely mobile but inoperable in reality because of liver metastasis, in the belief that the period of life thus given the individual is made more worth while.

Fixation to adjacent viscera or the abdominal wall may, under drainage procedures, loosen sufficiently in some cases to allow a secondary resection at a later time. One should remember that fixation usually comes from inflammation rather than from malignant extension. With this in mind, a growth considered as border-line or inoperable at the exploration, may eventually become sufficiently mobile after the recession of the inflammatory process to allow removal.

Again, there is a group of cases in which local fixation to adjacent viscera such as the bladder or uterus, demands multiple resections, such as complete hysterectomy or partial cystectomy, in addition to resection of the colon. I have operated in a number of such cases without increasing the mortality, but with unsatisfactory ultimate results. I believe, however, that such cases may be selected with justification under certain circumstances and that it is distinctly worth while to give these individuals a period of comfortable existence and let them return to their work, if it may be done without too much operative risk. Such procedures should always be considered as palliative and as involving a high operative risk. Indulgence in speculation on the percentage of operability in different hands, must necessarily be done with considerable trepidation because of the many factors concerned. My own experience has been that an operability of one out of two cases is about what may be maintained over a period of years. Occasionally it will run as high as every two out of three, but more frequently one finds the fifty per cent range fairly accurate. That this should be maintained with an operative mortality ranging from 5 to 10 per cent, leaves the impression that this is a satisfactory standard in this particular field.

OPERATIVE MANEUVERS

That a graded operative procedure should be employed most often in extirpation of colonic growths is, I believe, the experience of most surgeons. That there are disadvantages to this type of procedure cannot be readily denied, yet the advantages seem to me distinctly to outweigh them. Technically, choice in operations on the two halves of the large bowel differs because of the type of pathological processes present, the presence or absence of obstruction, and local complications such as fixation, abscess formation, and attachment to adjacent viscera. Nevertheless, because of the greater safety of multiple stage procedures despite the numerous problems involved as well as the inconvenience of two laparotomies, I believe their value is proved. In the right colon, my choice is an ileocolostomy and exploration at the first stage, followed by a subsequent resection of the right half of the large bowel. If it seems advisable to accomplish the resection and anastomosis in one stage, I believe unquestionably that a complementary ileostomy proximal to the anastomosis should be done. I have many times, in operating for hyperplastic tuberculosis of the ileocæcal coil, resected the right colon in one stage, and occasionally I have attacked carcinomata by a single operation, but as a rule I believe the hazards are too great to undertake it except in highly selected cases.

The ileocolostomy which is done at the preliminary stage of the multiple maneuver plan accomplishes a drainage which in turn permits recession of the inflammatory process around the growth, and also is of great advantage in the patient's rehabilitation, increasing his resistance against another formidable extirpative act, and simplifying at the same time the secondary procedure. In performing the ileocolostomy, I would emphasize the desirability of making the anastomosis end-to-side between the terminal ileum and the transverse colon. My own choice is to do this over a clamp which I have designed, making an aseptic type of juncture. This aseptic end-to-side anastomosis over the clamp is simple of accomplishment, and I think possesses definite advantages. The instrument is not bunglesome. The procedure may easily be done by anyone, and in an experience of 100 consecutive cases, which include in addition to our 60, those cases reported by other surgeons, there has not been a single postoperative hæmorrhage. This is an objection frequently offered against anastomosis done over crushing clamps. In my own series there has been no instance of obstruction at the site of anastomosis, nor has there been any leakage at the suture line, although two patients died and autopsy revealed evidences of peritonitis in one. In this case there was no leakage, and it was the conclusion that the peritonitis came from the large infected growth.

In my series of 62 ileocolostomies there were four operative deaths, a percentage of 6.4. While I do not believe that the aseptic type of anastomosis is of paramount importance, there is little question that the cleaner the anastomosis, the less likelihood of subse

quent contamination, and consequently if one may do this anastomosis with the ease and comfort with which an open anastomosis may be accomplished, and without complications of obstruction and hæmorrhage, the advantages are definite. Like vaccination, I consider the aseptic type of anastomosis as but one of a sequence of events aimed at successful surgical attack on right colonic cancers. Of the utmost importance I think, however, is the manufacture of an end-to-side opening between the terminal ileum and the transverse colon to by-pass the fæcal current, thereby reducing the local infection, intoxication, and dehydration, and the promoting with other measures, of rehabilitation.

The second stage of this maneuver is carried out at a later date with from 2 to 6 weeks intervening as a rule. This is easily done with exploration having been made at the first operation and the resection being the main matter in hand. At this time one mobilizes the right colon, ligates its blood supply, divides it between clamps with a cautery, turns in the end of the bowel, and peritonealizes the raw surfaces quickly. It is best to drain the retroperitoneal pocket left because of the tendency of serum to collect in this space and the likelihood of it becoming infected and forming an abscess.

When the growth is situated beyond the middle of the transverse colon down to as far as the juncture of the middle and lower thirds of the sigmoid, the choice of operation in my hands has been an obstructive type of resection when a chronic or subacute obstruction has been eliminated by pre-operative precaution. Let me emphasize the desirability of complete pre-operative decompression of the bowel before this type of maneuver is employed. This obstructive resection, however, utilizes all the satisfactory fundamental principles of the exteriorization operations and avoids most of their disadvantages. In mobile segments of the large bowel it has proved most satisfactory in my hands. By mobilizing the bowel accurately, ligating the blood supply in the mesentery, and removing the lymphatics and gland bearing tissues in the immediate vicinity of the growth, one may in this manner perform just as radical a resection as may be carried out by any type of procedure. The three bladed clamp is left on the ends of the bowel, and the toilet of the peritoneum completed, leaving the colon completely obstructed for a period of 48 to 60 hours. At the end of this period the proximal blade is released. If gas has formed in the colon it blows open the colostomy, otherwise it may be necessary to pick it open with tissue forceps.

The subsequent steps of the operation are completed exactly as in the Mikulicz procedure. We have found these wounds singularly free from infection and with a tendency to close spontaneously at the end of about 2 months if enough spur has been removed between the two stomas, and the mucous membrane has not been left attached to the skin.

There is a distinct advantage in employing the Mikulicz operation occasionally, but I feel certain that its limitations are much greater than are usually conceded by most surgeons. It is impractical in cases of adherent growths associated with infection of the bowel wall and adjacent tissues, and large growths associated with infection or obstruction, and for growths in a sigmoid with a short mesentery, or in obese patients. My own application of it is in thin, elderly individuals without obstruction, possessing a carcinoma in a mobile segment of the large bowel and yet physically unable to stand any extensive operative act. Usually this type of case can be best explored under local anæsthesia, the bowel brought out on the abdominal wall, and the wound closed loosely around it. I think that it is never desirable to ligate the blood supply of the segment of the bowel to be sacrificed in order to make it mobile enough to perform an exteriorization operation. Under these circumstances, the growth and the loop of bowel in which it is situated early become black and foul-smelling and infection quickly takes place not only in the abdominal wound, but occasionally reaches into the peritoneum causing peritonitis.

Where neither an obstructive resection or some type of resection and anastomosis can be done because the bowel is insufficiently decompressed, it is desirable to perform either a cæcostomy or a colostomy as a drainage

measure. Subsequent resection of the colon may then be carried out either as, first, a resection and anastomosis, or second, as an obstructive resection. Cæcostomy as a drainage type of maneuver preliminary to subsequent resection of the left colon or rectum is a most desirable procedure. If one uses a large Pezzer catheter and introduces it into the cæcum after Hendon's method, one is able to decompress the bowel sufficiently in a period of from a few days to a few weeks. It has the distinct advantage of placing the artificial stoma away from the wound, through which the second stage is performed.

Whipple very aptly summarizes the advantages of cæcostomy as a preliminary measure as follows: (1) it makes possible proper cleansing of the colon before resection; (2) it permits the part anastomosed to be at rest until the period of fibroplasia is complete; (3) it increases the comfort of the patient by reducing the pain of ineffectual peristalsis; (4) it obviates the temptation and necessity in some cases, of giving enemas and irrigations in the critical period of repair; (5) in cases of partial or complete obstruction of the colon and rectum, it has long been recognized as essential and if it works so well for patients who are so desperately sick, it is even more efficacious in the case without obstruction.

I have not felt inclined for a long time to attempt a primary resection and anastomosis in the left colon with or without complementary decompression. While I feel certain that many times this may be safely done, I believe the attendant dangers of primary anastomosis are too high to employ it in anything like a routine manner. The blood supply of the colon is constant but scanty as compared with that of the stomach and small bowel. Infection is always present to retard rapid healing as has been shown by numerous investigators who have measured the rate of healing of various tissues.

There is danger of necrosis at the danger line of leakage. The question of secondary resection of the left colon then resolves itself in deciding whether or not to resect and anastomose or to do an obstructive resection at the second stage. My own experience in doing an obstructive type of resection at the second stage has been a satisfactory one and I have found small additional risk in closing the two stomas subsequently over the closing of a single one.

These graded procedures both in the right and left halves of the colon, may be undertaken as a general rule, with a hospital mortality rate ranging from 5 to 10 per cent without sacrificing the operability ratio, which should rarely be lower than one out of two, or which occasionally may run as high as two out of three cases. That the prognosis is favorable, is easily demonstrated, yet there is ample opportunity for improvement if one may receive these cases at an earlier period in their development.

I believe that it is undeniably true that more patients with carcinoma of the bowel and rectum are appearing at an earlier stage, yet the average of ten months or more of symptoms prior to examination leaves much to be desired. Roentgenographic efficiency in the diagnosis of organic lesions of the large bowel has been markedly forwarded in the last decade. Improvements in technique have followed the diagnostic pace, and a better understanding of pre-operative and post-operative management has reduced the mortality curves.

FRACTURES OF NECK OF FEMUR, DISLOCATIONS OF HIP, AND OBSCURE VASCULAR DISTURBANCES PRODUCING ASEPTIC NECROSIS OF HEAD OF FEMUR

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THE structure of the hip is such that certain types of injury are particularly apt to damage blood vessels to the head or head and neck of the femur. Because of inadequacy of collateral circulation this may result in aseptic necrosis of the bone and articular cartilage supplied by the damaged vessels which is an important factor in the causation of non-union of fractures of the neck and flattening and other deformities of the head, with their poor functional results. Santos reported earlier studies on the subject in this clinic and the present report deals with a continuation of that work. Interference with the blood supply of the head of obscure origin also results in similar necrosis and breaking down of head, especially during childhood. Aseptic necrosis is responsible for deformities and poor functional results in fractures of other bones bordering on other joints, as of the carpal navicular, and the body of the astragalus, as previously reported (18).

The head and mesial three-fifths of the neck of the femur lie within the cavity of the hip joint. The round ligament connects head with acetabulum. The intra-articular portion of the neck is covered by a capsule which, during the major period of longitudinal growth, functions as periosteum, but which in adult life is almost completely devoid of osteogenic properties. The head and neck considered as a unit may receive blood supply from three arteries, namely, the posterior cervical, the anterior cervical, and the round ligament. It is generally agreed that the blood supply of the neck is derived from the cervical arteries, largely the posterior cervical, but when the blood vessels of the head are considered, there is much disagreement as to the relative importance of those coming by way of the round ligament, the capsule of the neck, and the interior of the neck; also, as to the extent and location of anastomosing and end arteries during both the periods of growth and adult life. In fact, the anatomical, pathological, and animal experimental evidence which has accumulated since Sir Astley Cooper, in 1820, first called attention to the subject, would indicate that there is a good deal of variation in these vessels with the individual.

In the newborn, studies of the injected vessels with roentgenograms or after clearing by the Spalteholtz method, show round ligament and capsular arteries sending branches into the cartilaginous capital epiphysis. After the appearance of the center of ossification there is a difference of opinion as to the extent to which each of these arteries penetrates it. Langer and Lexer, from injection experiments, thought that they demonstrated arteries from the round ligament which were of importance for its blood supply during the period of growth. They also found injected vessels within the head coming from the superior and inferior neck arteries of the capsule, and from arteries within the neck which penetrate the cartilage plate to reach the center of ossification. Nussbaum (15), in similar studies, found few or no injected vessels of the head coming from the round ligament, and none penetrating the cartilage plate from the neck. He thought that the vessels of approximately two-thirds of the head came from the superior neck artery and of the remaining third from the inferior neck artery.

As to anastomoses and end arteries during the period of growth, Langer considered that both metaphysis and epiphysis contain end arteries but that there are also anastomoses between the primary arteries of each region. Nussbaum (16), from studies of injection specimens, has recently claimed that the metaphysis contains end arteries but that none are present in the epiphysis. Reports of the results of animal experiments are conflicting. Division of the round ligament in young

animals in some instances has produced necrosis of bone adjacent to the fovea but not in others. Bonn and Stewart found little or no necrosis after division of round ligament and no subsequent flattening of the head. Nussbaum reported necrosis and flattening of the bone of the head and thickening of the articular cartilage. Zemansky and Lippmann found slight necrosis in each of 7 rabbits, 1 of which showed flattening of the head after 35 days.

Experimental bland embolism as reported by Wollenberg and localization of pathogenic bacteria, which presumably often results from embolism, are rarely observed in the epiphyses but are seen in the metaphyses. This speaks against the existence of end arteries in the epiphyses and for their occurrence in the metaphyses. Metaphyseal foci only were observed by Lexer after injections of staphylococci, and by Schulze after injections of tubercle bacilli.

Stewart found that cutting both round ligament and vessels of the capsule of the neck in young animals results in necrosis of the bone of the capital epiphysis more frequently and more extensively than division of round ligament alone, but even then in both dog and rabbit it often fails to follow. In such cases there must be anastomoses between the internal vessels of the neck and the epiphyseal vessels. These may penetrate the epiphyseal cartilage plate, as claimed by Lexer and Schulze or pass about its periphery.

In adults there are definite anastomoses between the vessels of the interior of the neck and head. Consequently the head is less dependent upon the vessels coming by way of the neck capsule. Capsular vessels are present, although in some cases they are small and of little service in nourishing the head, as shown by death of head in fracture of neck, even though much of the capsule is untorn (Schmorl).

As to vessels entering the head by way of the round ligament during adult life, it is now established that they are present in the majority of cases but that their size varies greatly. Chandler and Kreuscher recently studied 114 round ligaments from cadavers of persons ranging in age from 25 to 75 years. Arteries were found in all of them. Fifty ligaments showed vessels with lumina ranging from .04 to 1.05 millimeters in diameter. Microscopic sections of the fovea were made in some cases and the vessels were seen to enter the bone. They were of sufficient size to be of importance in supplying blood to the head. In the remaining ligaments the arteries ranged downward in size to pre-capillaries and in many cases were too small to have played an appreciable rôle in supplying blood to the head.

The existence of end arteries in the bones of adults has been generally denied by those studying the subject purely from an anatomical standpoint. Necrosis and collapse of the head of the femur following dislocation of the hip in adults as reported by Chandler and Kreuscher and by Stewart, and in this article, proves the existence of end arteries in that region. Axhausen (3) also found infarcted areas in the tibia and femur of an adult as a result of vascular blockage.

Turning from these anatomical and experimental data to study certain injuries and diseases of the hip in man, we discover important facts about the blood supply of the femoral head and the results of its injury which could scarcely be elicited in any other way since experiments happen in nature that cannot well be duplicated in experimental animals. They will be considered under the head of fractures, dislocations, slipped epiphysis, injuries to vessels alone, and disturbances of vessels of unknown cause.

FRACTURES

The fractures causing necrosis may be of the intracapsular or extracapsular portions of the neck or of the greater trochanter. The last two are extremely rare.

Intracapsular fracture of the neck of the femur. In this injury the blood supply of the head may be maintained through vessels entering by way of the round ligament or untorn portions of the capsule, or by both. It may also be either partly or completely destroyed in case the vessels coming by way of the neck are completely severed and those of the round ligament are too small to maintain the circulation. In that case a part or all of the head of the femur becomes necrotic. In the case of either survival or death of the head, the frac-

ture may unite or remain ununited. Consequently the result will be one of four conditions: (1) survival of head with bony union; (2) survival of head with non-union; (3) necrosis of head, partial or complete, with bony union; (4) necrosis of head, partial or complete, with non-union.

It is generally recognized that it is possible to determine in 2 to 4 months by clinical and roentgenological examination whether or not bony union has occurred. However, an important fact not generally recognized is that it is also possible to determine from roentgenograms in 2 to 5 months in the great majority of cases especially of non-union whether head has remained alive or has undergone partial or complete necrosis. This information has been derived by correlation of roentgenological studies of fractured hips with roentgenological and pathological studies of heads obtained at operation, or entire upper ends of femurs obtained at autopsy on these cases. Seventeen specimens of fractures from 15 days to 4½ years after injury have been studied in this way. They were obtained at operation in 14 cases and at autopsy in 3. Pathological examination showed survival of the head in 3 cases and partial or complete necrosis of it in 14. The roentgen diagnosis is possible because recognizable differences in density develop between the dead and living portions, and there is slow creeping replacement of the dead bone by spongy living bone of low density.

Since these diagnostic methods have been used, 49 cases have been studied in which sufficient time had elapsed to make it possible to say from roentgenograms, and in 17 of the cases from pathological examination, whether the head was alive or necrotic, and whether there was union or non-union. The results were as follows: survival of the head—17 cases, with union in 8 cases and non-union in 9; necrosis, partial or complete, of the head—32 cases, with union in 4 and non-union in 28. Thus, there was bony union in 25 per cent of all cases. The head survived in one-third of the cases and there was bony union in approximately half of these. In two-thirds of the cases the head underwent partial or complete necrosis, and there was bony union in only one-seventh of these. This shows the great importance of necrosis in the proximal fragment as a cause of non-union of intracapsular fractures of the neck of the femur. However, the series most probably gives an exaggerated picture of the frequency with which necrosis of the head of the femur occurs, since it does not represent a series of fresh cases; most of them were studied long after the hip fractured because of a bad result, and when non-union was found to exist.

INTRACAPSULAR FRACTURE OF THE NECK WITH SURVIVAL OF THE HEAD AND BONY UNION

Knowledge of the subject has been derived largely from long term roentgenological studies and pathological studies of recent cases, only 1 late case, No. 12 of Santos, having been studied pathologically.

The fracture is in the mesial portion of the neck. In the great majority of cases of intracapsular fractures of the neck, regardless of whether the head remains alive or the fracture unites the periosteum or capsule of the neck is torn in only a part of its extent (Schmorl), the posterior portion being especially apt to remain intact. The blood supply of the head is preserved by the vessels of the round ligament or/and of the untorn portion of capsule. It is difficult to say which of the two is the more important. Three fractures of the neck with survival of the head, in this series, were studied at autopsy 15 to 24 days after injury, and all were found to have a portion of the capsule untorn. Transverse sections of the untorn capsule in 2 cases showed vessels that were large enough to play a considerable rôle in the blood supply of the head. Figure 1, Case 1, gives some idea of the extent of untorn capsule that may be present. It shows an intracapsular fracture of the neck in an 80 year old man who died 3 days after injury. In the anterior view the fracture and intact round ligament and in the posterior view the untorn portion of capsule are shown. While it was too early to determine whether the head was dead or alive, microscopic examination of the untorn capsule showed the presence of blood vessels of considerable size.

The sequence of pathology when the head remains alive and union takes place is as follows: The apposition and fixation of fragments

is usually satisfactory as otherwise non-union is the result. Union occurs most often when the fracture is impacted. Necrosis of cortex of both fragment ends for a short distance back from the fracture is to be expected as it is a regular occurrence in fractures of other locations, as shown by Cornil and Coudray. It was observed in Cases 2 and 5 of this series in which the time elapsed was sufficient for disappearance of the dead bone cells but insufficient for erosion of the end of the distal fragment. In some cases bony union occurs with preservation of neck fragments, especially when there is impaction. The callus forms almost entirely within the neck, the periosteum showing practically no osteogenic activity. The callus ossifies and practically no deformity is left except that which results from angulation of fragments. This and the increased density at the fracture line make it possible to locate the seat of the fracture in roentgenograms in some cases years after healing has occurred. Atrophy of disuse develops during the period of immobilization and healing. This is evenly distributed, being as marked in the head as in the distal fragment and acetabulum. The head never collapses and the articular cartilage is not destroyed. With resumption of function, after union is complete, the bone gradually increases in density and after several months the density may return to normal. If the position of the head has been much altered new trabeculæ will be formed in it along the new lines of weight bearing. Increasing age does not appear to lessen the frequency of survival. In one case there was bony union and survival of head in a woman, aged 96 years, as shown by a series of roentgenograms during 4 succeeding years.

The X-ray diagnosis of survival of head and bony union may be made on the following points: There is uniform reduction of density of all of the bones of the hip during the period of immobilization and healing the change being as marked in head as in distal fragment of femur. Density develops along the fracture line from callus formation. With resumption of function the density of the bones gradually and uniformly increases until it is as heavy as before. There is no sign of collapse of the head or narrowing of cartilage space of joint.

Figure 2 is a roentgenogram of the hip of Case 14, reported by Santos, showing the condition 5 years after fracture. The function of the hip is normal. The head is angulated slightly outward, and there is an irregular line of increased density along the site of the old fracture. The density is of the same degree and uniformity in the head as in the shaft and the shadows of articular cortex and cartilage space of the joint are intact.

The pathological changes in the early stages of neck erosion are illustrated by Case 2.

A female, aged 75 years, fractured the neck of the right femur 15 days before death. In addition to the fracture of the neck the capsule was torn anteriorly, but the posterior portion of capsule was intact. The distal fragment was upwardly displaced and its cortex had gouged into and eroded cancellous bone of the proximal fragment. This is shown in a microscopic section through head and neck (Fig. 3). Microscopic examination showed the bone alive in both proximal and distal fragments except along the fracture lines. There was death of cortex of the distal fragment for ½ to 1 centimeter back from the fracture line. Fibrous callus filled the cancellous spaces on both sides of the fracture to a depth of ½ to 1 centimeter and bony trabeculæ along the surfaces were dead, fragmented, and in many places ground into the underlying cancellous spaces as shown in Figure 4.

Erosion of the neck was well under way in this case, and there was considerable necrosis of cortex of the distal fragment adjacent to the fracture line. Non-union might have been the result but delayed union after more erosion of the neck might have occurred.

In other cases of fracture of the neck with survival of the head, the neck fragments may be extensively eroded over a period of months as a result of incomplete fixation and friction. Callus may then be thrown out and bony union between the head and stump of neck may take place giving a satisfactory functional result. This was true in Case 12 of Santos' series which was confirmed at autopsy 4½ years after injury.

Case 3. This illustrates survival of the head with markedly delayed union and partial erosion of neck fragments. A female, aged 56 years, fell on the left hip and sustained an intracapsular fracture of the neck (Fig. 5). Treatment was by the Whitman abduction cast method for 53 days at which time a roentgenogram (Fig. 6) showed the fragments in good position and regional atrophy as marked in the

head as in the distal fragment. Callus formation was questionable. Because of coexisting chronic polyarthritis the treatment from this time onward was by rest in bed. Figure 7, 131 days after injury, shows further regional atrophy uniformly distributed and upward displacement of the lower fragment with considerable erosion of fragment ends. A roentgenogram 8¼ months after injury showed beginning bony union. Figure 8 shows bony union complete 14½ months after injury, and Figure 9 the reconstructed neck and the partially reconstructed malposed head at the end of 2 years and 5 months. There is some irregularity of articular cortex and cartilage space at the top of the head which is probably the result of the degenerative arthritis attributable both to the coexisting disease and to the malposition following the fracture. Uniform atrophy of disuse is still present.

This case emphasizes the necessity for continued treatment in the presence of delayed union, in the hope bony callus may form late, even after considerable erosion of the neck.

Occasionally degenerative arthritis develops many years after bony union of an intracapsular fracture with apparent survival of the head and a good functional result.

CASE 4. Figure 10 shows roentgenograms of the hip joint of a female, aged 72, who 10 years previously sustained an intracapsular fracture of the femoral neck which was treated by the abduction cast method for 4 months. There was complete return of function and freedom from pain for 8½ years. She then developed pain on walking which persisted and finally led to slight limitation of motion. Figure 10, left, taken 10 years after injury shows slight narrowing of the cartilage space and sclerosis of bone along the weight bearing portion of the joint. The symptoms progressed slowly. Figure 10, right, the condition 2 years later. Cartilage space is lost and subchondral sclerosis is marked in both head and acetabulum in the weight bearing portion. Slight coxa valga and irregularity at the fracture line are still present as evidence of the old, healed fracture.

The reason for the arthritis is not clear. Keefer and Myers have called attention to degenerative arthritis in various joints following trauma. There exists the possibility that in this case the head suffered necrosis and was completely transformed without collapse, but the very long period of freedom from symptoms following the fracture speaks against it.

INTRACAPSULAR FRACTURE OF THE NECK WITH SURVIVAL OF THE HEAD FOLLOWED BY NON-UNION

If the head remains alive and the fracture fails to unite, there is always gradual erosion of the neck fragments which continues until the proximal portion of the neck is destroyed, leaving only the head in the acetabulum. In some cases a considerable amount of distal fragment of neck persists, especially in its lower portion. Figure 11, Case 5, shows the marked erosive effect of the more dense inferior cortex of distal fragment on the proximal fragment when the hip is not immobilized. It is a roentgenogram of the upper end of the femur excised from a 90 year old woman who sustained a mesial neck fracture (untreated) 20 days before death from pneumonia. The posterior capsule of the neck was untorn and it and the round ligament contained blood vessels ample to keep the head alive. The lower cortex of distal neck fragment which had severely eroded head showed extensive necrosis of bone cells.

Atrophy of disuse gradually develops and becomes marked. It is of equal intensity in both head and distal fragments. The head retains its form and the cartilage space of the joint is preserved.

Case 6 illustrates the gradual erosion of the neck and the extreme even reduction in density which eventually ensues.

CASE 6. A female, aged 53 years, fractured the neck of the left femur, as shown in Figure 12. A Whitman abduction cast was applied for 76 days at the end of which time a roentgenogram (Fig. 13) showed marked regional atrophy uniformly distributed in both fragments and questionable callus formation. Motion was then allowed and the patient walked on crutches. Figure 14 shows the result 11 months after fracture. Neck fragments are eroded and there is extreme regional atrophy which is equally marked in pelvis, head, and distal fragment, indicating the survival of the head with non-union of fracture.

If the non-union is successfully treated by open operation, the atrophy of disuse gradually disappears with the resumption of use and a good functional result is obtained. This is illustrated by Case 7.

CASE 7. A female, aged 45 years, sustained an intracapsular fracture of the neck of the femur which was treated for 128 days by an abduction cast combined with extension. A roentgenogram, Figure 15, then showed upward displacement and non-union of the fracture with marked but uniform regional atrophy affecting equally both head and distal fragment. The shadows of the fragments of the lower portion

of the neck overlap giving a dense appearance. The patient was then operated on by Dr. Donald C. Keyes, the fragments being reduced and fixed by an autogenous tibial graft. Figure 16 shows bony union 10 weeks later but both head and distal fragment are still uniformly atrophied. Use of the limb was then resumed and the function gradually returned almost to normal, with freedom from pain. Figure 17, taken 23 months later, shows density restored to normal and equal in the two fragments with preservation of articular cortex and the normal width of cartilage space.

Bony union was obtained in another patient operated on similarly 10 months after fracture.

When there is non-union and a living head, operation with appropriate approximation and fixation of head to shaft offers good chances of bony union. The Brackett operation or its modification by Magnuson has given successful results. An autogenous bone graft, as employed in this case, is probably the best material to use for fixation although screws and nails, such as the one devised by Smith-Peterson, have also been used with variable degrees of success, and are more easily applied.

Cases of non-union with living head that are left untreated for long periods usually show marked atrophy and upward displacement of the trochanter. After neck erosion is complete, a cortex usually forms along the eroded surfaces and adhesions develop between these and the capsule which, on examination at operation or autopsy, may be found infolded. With fibrous fixation there may be a gradual increase in weight bearing power of the hip, and the patient may be able to do a moderate amount of walking without crutch or cane. With usage the density of the bones gradually increases and new trabeculæ may be laid down in the head as a result of pressure of distal fragment upon it in an abnormal direction. The cartilage space and the shadows of articular cortex are preserved in such cases. The late result is illustrated by Case 8.

CASE 8. A male, aged 68 years, suffered a fracture of the hip 12 years previous to examination. Non-union with shortening of the limb resulted but he had been able to do a moderate amount of walking without crutch or cane for 10 years with but little discomfort. A roentgenogram (Fig. 18) showed complete loss of neck with close approximation of head and intertrochanteric region and increased density indicating osteosclerosis along the eroded fracture surfaces. The density of the bones of the hip was slightly reduced but was equal in head and surrounding bone. Cartilage space of the joint was of normal width. The bony trabeculæ of head and intertrochanteric region were irregularly arranged as a result of stresses acting on the fragments in malposition.

It has been found at operation that a living head in case of non-union is usually free from adhesions over its articular surface. This probably accounted for the wide range of mobility in 2 such cases in this series in which bony union followed a bone pegging operation.

INTRACAPSULAR FRACTURE OF THE NECK WITH NECROSIS OF HEAD FOLLOWED BY NON-UNION

Necrosis of a part or all of the head follows fracture of the neck if the blood supply is too extensively cut off by the injury. Schmorl, Hesse, Nussbaum, and Santos have described the pathological changes in several cases. Fourteen excised heads showing partial or complete necrosis have been examined pathologically in this series. They were removed from 2 months to 4½ years after the fracture occurred and showed not only different amounts of necrosis but also different degrees of organization of the necrotic portion. In 6 cases the necrosis appeared to have been total, in 3 cases partial, and in 5 cases the examination was made so long after injury and the transformative changes were so marked that it was impossible to determine whether the necrosis had been partial or complete.

In 15 additional cases the diagnosis of necrosis in the femoral head has been made from roentgenological examination only, based on criteria established by the correlation of pathological and roentgenological findings in the other group.

If capsule of neck is completely torn there is much greater likelihood of necrosis than if it is partially intact. However, complete necrosis may occur when much of the capsule is intact, as in Case 8 reported by Santos. Necrosis may occur in the presence of impaction of fragments as shown by the same case.

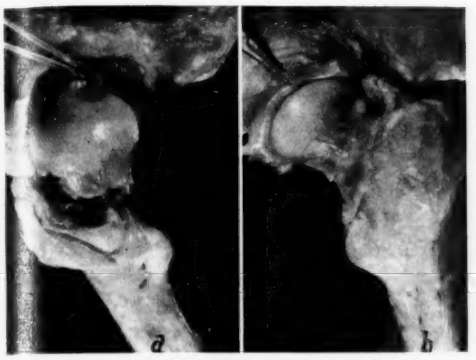

Fig. 1. Case 1. Five days after injury. a, Anterior view; neck fractured and capsule torn. b, Posterior view; capsule untorn.

The early changes which occur in the necrotic area consist of disappearance of the cells of both the bone and the marrow. If a portion of the head remains alive, it is likely to be near the fovea or in the inferior part where the blood supply is derived from round ligament or untorn capsule. Atrophy of disuse gradually develops in the distal fragment, in acetabulum and in case of partial necrosis in the surviving portion of the head. The necrotic bone does not atrophy but retains its original

Fig. 2. Healed intracapsular fracture of neck with survival of head 5 years after injury. Equal degree of density of head and shaft.

density. Consequently after 2 to 4 months of disuse it casts a heavier shadow in roentgenograms than the surrounding atrophied living bone. The neck fragments are gradually eroded. The dead bone is gradually invaded by connective tissue which replaces the dead marrow. If the entire head is dead the invasion is by way of the round ligament and untorn portions of the capsule in the earlier

Fig. 3. Case 2. Section of upper end of femur showing 15 day old intracapsular fracture of neck with survival of head. Fibrous callous in fragment ends. Death of cortex of distal fragment of neck beyond points *a* and *b*.

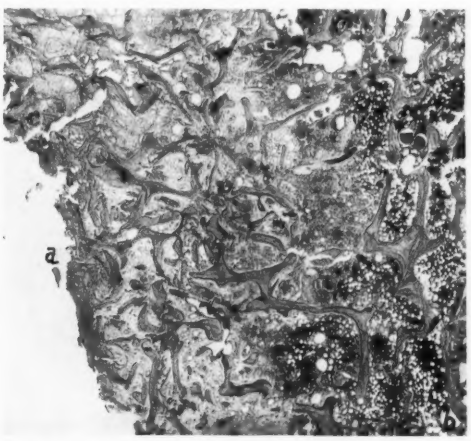

Fig. 4. Case 2. Photomicrograph showing fibrous marrow and eroded dead trabeculæ along the surface of the fragment end, *a;* bone and marrow of deeper portion alive, *b*.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 5. Case 3. Fresh intracapsular fracture of neck. Subsequent figures show survival of head and delayed union.

Fig. 6. Case 3. Fifty-three days after receipt of injury. Atrophy was equally marked in both the fragments, indicating the survival of the head.

Fig. 7. Case 3. Roentgenogram 131 days after injury. Delayed union, displacement of fragments, and some erosion of neck. Atrophy equal in the two fragments. Survival of head and delayed union of fracture.

stages; later it may be by way of adhesions. If a portion of the head remains alive, connective tissue grows out from its margin and invades the dead bone.

Behind the zone of invasion comes a zone of transformation of the dead bone. The invading connective tissue of the marrow spaces is embryonal and differentiates into bone and bone marrow. Some of the old bone is absorbed while some of it has new bone laid down on its surface and is gradually replaced by it through the process of creeping substitution. Wherever new bone is laid down new bone marrow containing both hæmopoietic and fatty cells is also formed. The new bone is usually much more spongy than the old bone which it has replaced and defects are sometimes left filled with marrow which in the X-ray give a cystic

Fig. 8, left. Case 3. Bony union 14½ months after injury. Atrophy still equal in the two fragments.

Fig. 9. Case 3. Reconstructed neck and newly formed trabeculæ in weight bearing portion of head and neck 2 years 5 months after injury.

Fig. 10. Case 4. Intracapsular fracture of neck with survival of head and bony union. Arthritic symptoms began 8½ years after injury. Left, roentgenogram after 10 years; right, after 12 years.

appearance. The rate of connective tissue invasion and creeping substitution of the dead bone is slow, requiring several months to years for completion, depending largely on the extent of the necrotic area.

Articular cartilage very slowly dies when its underlying bone is necrotic as the great bulk of the nutrition comes from the bone. However, some nutrition comes from the synovial fluid as shown by Nussbaum and cartilage cells are sometimes kept alive by it for long periods. If the underlying dead bone is rapidly absorbed and replaced by new bone the cartilage may be revived and persist. This was observed in animal experiments to be reported and in one human case 2 months after fracture. Pieces of cartilage chipped off by the fracture may remain free in the joint. Their surviving superficial cells may proliferate and after years form oval loose bodies nourished by the synovial fluid as was found at operation in 2 cases of this series. The nuclei of the dead cartilage on the head break down very slowly and those near the bony attachment sometimes may not completely disappear for 2 or 3 years. The dead cartilage is usually slowly absorbed in the course of 3 or 4 years and replaced by a thin layer of fibrocartilage or fibrous tissue. Sometimes the opposing articular cartilages become adherent and are simultaneously absorbed narrowing the cartilage space of the joint. Articular cartilage overlying living portions of the head remains alive.

Fig. 11. Case 5. Erosion of deep hole in head by inferior cortex of lower fragment 20 days after intracapsular fracture in 90 year old woman.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 12. Case 6. Fresh intracapsular fracture of neck of femur. Female, aged 53 years.

Fig. 13. Case 6. Seventy-six days after fracture. Regional atrophy is equally marked in both fragments, indicating survival of the head; union is questionable.

Fig. 14. Case 6. Eleven months after fracture. Atrophy equally marked in both fragments. Neck eroded. Survival of head and non-union.

Case 9 illustrates partial necrosis of the bone and cartilage of the head with fibrous invasion and creeping replacement of the dead bone by new bone, in the act of occurrence.

Case 9. Female, aged 65 years, a teacher, fractured the intracapsular portion of the neck of the left femur and was treated for 20 weeks by the Whitman abduction cast method. A roentgenogram 152 days after injury revealed non-union with some erosion and displacement of fragments (Fig. 19). The pelvis and distal fragment showed reduction in density. Most of the superior and lateral portions of the head were denser than the surrounding bone and the shadows of the trabeculæ were as heavy as those of normal bone. The mesial portion about the fovea and the inferior portion were greatly reduced in density. The diagnosis was made of non-union and extensive necrosis in femoral head. Because of the necessity for restoring the economic efficiency of the patient as rapidly as possible, an operation for ankylosing the hip was carried out. At operation the fracture was found ununited and the neck fragments extensively eroded. A portion of the capsule was untorn posteriorly and the round ligament was intact. The head was excised, the cartilage of the acetabulum removed, the greater trochanter denuded and inserted into the acetabulum, and a whole thickness onlay tibial graft inserted. Bony union was present after cast immobilization for 12 weeks and walking was resumed after 5 months.

The neck portion of the proximal fragment was completely eroded. The articular cartilage was smooth and intact except where destroyed by erosion at the upper margin. A coronal section ½ centimeter thick was cut through the middle of the head, passing through the fovea. There was an irregular area bordering on the fovea and the inferior portion of the head which was dark gray in color and contained fine, spongy bone. The lateral and superior portion was lighter in color and composed of dense bone. The subcortical portion at the top of the dense area was yellowish in color. A fibrous band could be seen along the irregular line of junction of the dense and porous portions. A roentgenogram (Fig. 20) of the slice confirms the difference in density between the inferomesial and the superolateral portions and shows the normal arrangement of the old trabeculæ of the latter. Cortex above the fovea is of normal density while that below is irregularly reduced in density. A microscopic section of the slice (Fig. 21) confirms the size and arrangement of the trabeculæ in the two regions. On high power examination it was found that the articular cartilage and the old, dense bone in the superior and lateral regions were dead and that cancellous spaces of the bone were occupied by fibrous marrow except at the top where the old dead marrow was still present (Fig. 22). Dead or nicrobiotic cartilage and dead bone with cancellous spaces filled with fibrous marrow are seen in Figure 23. The inferomesial portion showed living bone and hæmopoietic marrow, the bony trabeculæ being very small and irregularly arranged. The articular cartilage from the inferior margin of the fovea downward was alive except for a short stretch at the neck margin, and its bony cortex was

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 15. Case 7. Roentgenogram which was taken 128 days after the fracture occurred. Atrophy is equal in the head and in the shaft. There is non-union with survival of the head.

Fig. 16. Case 7. Roentgenogram 10 weeks after the insertion of an autogenous bone peg. Atrophy is still equal in the two fragments.

Fig. 17. Case 7 Twenty-three months after operation. Bony union, density increased and uniform in both fragments; cartilage space preserved; living head and bony union.

extremely thin and in places incomplete (Fig. 24). This indicates survival of articular cartilage and some of bone of the inferior portion of the head due to preservation of its blood supply through round ligament and perhaps untorn capsule. The cells of the dead cartilage over the superior portion had largely disappeared. Creeping replacement of dead bone and fibrous marrow by living bone and hæmopoietic marrow is seen along the entire junction of the dense with the rarefied bone (Fig. 25).

Conclusions in this case from pathological examinations are that, as a result of the injury, all of the head except probably the regions of the fovea and the more superficial portions of the inferior part had blood supply cut off resulting in necrosis and non-union. The living cartilage on the under side of the head changed but little. The bone which remained alive underwent atrophy. There was fibrous invasion of the marrow spaces of all of the dead bone except an oval area at the top of the head, and creeping replacement was well under way in the dead bone bordering on the old bone that remained alive. It is almost impossible to distinguish between atrophied, old, living bone and the new bone which has replaced the old, dead bone except along the border where creeping replacement is actively going on. For this reason it is impossible to know how much of the live bone is old atrophied living bone and how much is new bone that has replaced dead portions.

Complete necrosis of the head is well illustrated by Case 2 of the series reported by Santos. Sixteen months after injury there was non-union of the fracture with erosion of the neck fragments. The head cast a uniformly dense shadow while the surrounding bone of pelvis and distal fragment showed marked reduction in density from atrophy of disuse (Fig. 26). A section of the excised head (*a*)

Fig. 18. Case 8. Non-union and survival of head 12 years after fracture. Atrophy uniform in the two fragments. Cartilage space of joint preserved.

Fig. 19. Case 9. Roentgenogram 152 days after fracture. Non-union and necrosis of most of the head; superior and lateral portions of head necrotic and dense; inferior mesial portion of head and distal fragment alive and atrophic.

showed some absorption of bone about the fovea with connective tissue invasion of the marrow space of its mesial half. The remaining whitish portion next to eroded neck surface still consisted of dead bone and uninvaded dead marrow. A roentgenogram of a slice of the head (*b*) shows that the old bone is still present except for a small area near the fovea where it was found on microscopic examination to be replaced by spongy new bone. All of the articular cartilage was dead, and some of it was replaced by fibrous tissue. The case illustrates the slowness with which fibrous invasion of the dead bone takes place and the marked delay which there may be in the creeping replacement of the dead bone by new bone. The diagnostic value of the difference in density between the dead bone and the atrophied living bone of pelvis and shaft is strikingly brought out in the roentgenogram.

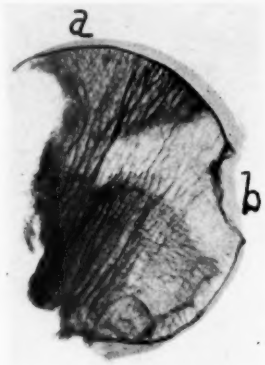

Fig. 20. Case 9. Roentgenogram of slice of excised head shows old trabeculæ unaltered in superior and lateral portions, *a;* inferior and mesial portions adjacent to fovea greatly reduced in density, *b*.

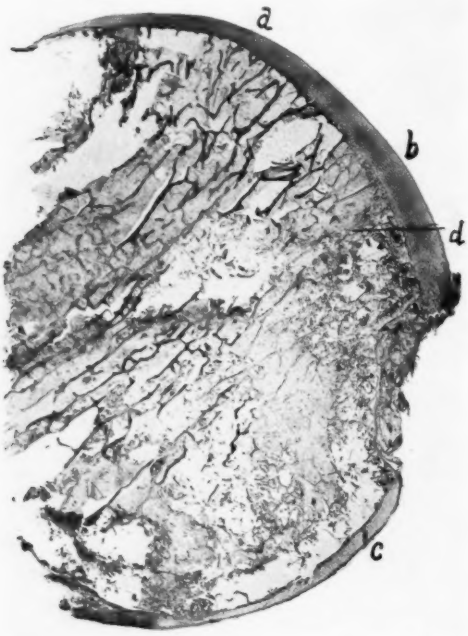

Fig. 21. Case 9. This photomicrograph confirms the findings demonstrated in Figure 20. Dead bone and marrow unchanged at *a*, dead bone and fibrous marrow at *b*, atrophic old living bone *c*, and irregular zone of creeping replacement along line of junction of dense and rarefied portions, *d*.

That necrosis of the head is a factor in the causation of non-union is demonstrated in Case 10.

Case 10. A female, aged 63 years, sustained an intracapsular fracture of the neck of the left femur. A roentgenogram showed marked upward displacement of the distal fragment. At operation 2 days after injury, the capsule of the neck was found completely torn. The fragments were approximated and fixed by a Smith-Peterson nail. Immobilization was continued for 2 months in a body and leg plaster cast. A roentgenogram 66 days after injury (Fig. 27) showed accurate approximation of fragments and questionable union. The shadow of the head appeared to be slightly denser than that of distal fragment, suggesting death of the head. The patient walked with crutches and after 4 months bore some

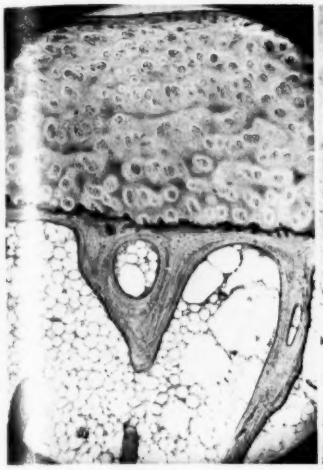

Fig. 22.

Fig. 23.

Fig. 24.

Fig. 22. Case 9. Dead bone, cartilage, and marrow at *a* in Figure 21.

Fig. 23. Case 9. Dead cartilage and bone with cancellous spaces filled with fibrous marrow at *b* in Figure 21.

Fig. 24. Case 9. Living cartilage and atrophied old living bone at *c* in Figure 21.

weight on the limb. A series of roentgenograms showed gradual absorption of neck and upward displacement of shaft, with downward tilting of the nail. Atrophy of disuse increased in pelvis and shaft of femur. The head of the bone, however, remained dense except in the regions of the fovea and mesially below the nail, where a gradually enlarging area of reduced density developed. Figure 28 shows the condition 13½ months after injury. A roentgenogram 1¾ years after injury showed further transformation with only about two-fifths of the old dense area remaining. The nail was then removed, which lessened the discomfort on walking which the patient had experienced for more than a year.

A small amount of head supplied by blood through the ligamentum teres may have remained alive about the fovea and atrophied but the gradual enlargement of the area of reduced density was undoubtedly brought about by creeping substitution of the dead bone by spongy new bone. However, cases of necrosis in femoral head with non-union of short duration, in which neck erosion is absent or not marked, may be operated on and bony union obtained followed by rapid creeping substitution of the dead bone by new bone. The head should be adequately protected from weight bearing during the period of transformation in order to avoid breaking down of the dead bone and deformity. A good result was obtained in Case 14 (Fig. 38) of this series, although a small portion of the head was detached.

Case 11 shows the slow rate of transformation of the dead bone in long standing necrosis of the upper part of the head and the satisfactory result which was obtained after bony union obtained by the Brackett operation.

Case 11. A female, aged 58 years, fractured the neck of the femur 3 years before admission. She was treated originally by bed rest with weight extension for 3 months, after which she walked with crutches.

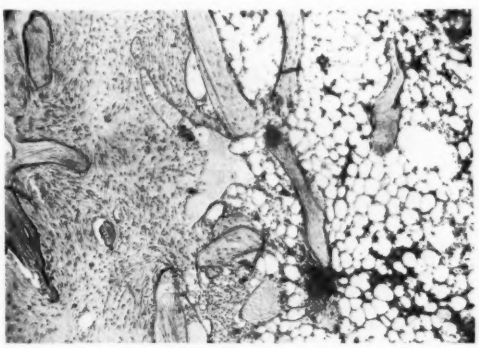

Fig. 25. Case 9. Junction of dead and new living bone at *d* in Figure 21. Creeping substitution of dead bone and fibrous marrow *a* by spongy living bone and hæmopoietic marrow *b*.

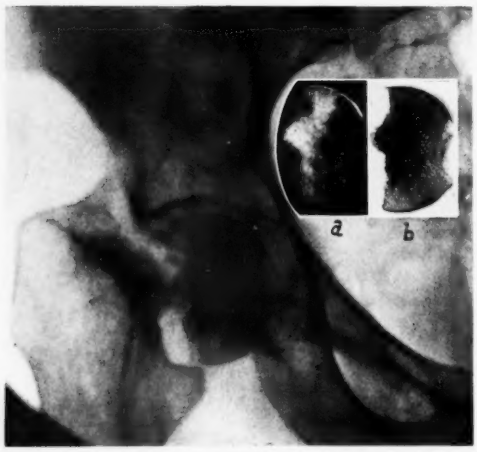

Fig. 26. Sixteen months after fracture. Non-union and complete death of head. Excised head, *a*, shows fibrous invasion mesially, *b*, slight absorption and bony replacement at fovea. Light portion laterally uninvaded. Old dead trabeculæ shown in roentgenogram of slice.

A roentgenogram on admission (Fig. 29) showed non-union of fracture and loss of femoral neck. Pelvis and shaft of femur showed great reduction in density. The density of the head of the femur was greatly reduced, except at the top, where a cone-shaped area had the original density of the bone. Cartilage space of joint was normal in width, and the shadow of articular cortex of head was intact, although greatest over the dense area. A diagnosis was made of necrosis in the head of the femur, the original extent of which could not be stated at this time but an island of which still persisted.

A Brackett type of operation was performed by Dr. C. Howard Hatcher which gave bony union after 10 weeks of plaster cast fixation. A useful movable and almost painless hip was obtained with 2½ inches of shortening of the limb. Figure 30 shows the result 1½ years later. Dense new bone formed across the fracture line and replaced old dense bone in the weight bearing portion of the head.

The case shows that after the dead bone has been largely replaced by living bone, an operation may result in union of the fracture and a useful limb.

In the course of a few years all of the dead bone may be replaced by new bone, and the dead cartilage by fibrocartilage or fibrous tissue. The head then consists of spongy bone with a frail and irregular articular cortex. The cartilage space of the joint is usually narrowed. There may be cavity-like areas in the head. These features may make possible the X-ray diagnosis of complete substitution of a partial or complete necrosis of the head, as in the following instance.

CASE 12. Female, aged 53 years, sustained an intracapsular fracture of the neck of the femur which

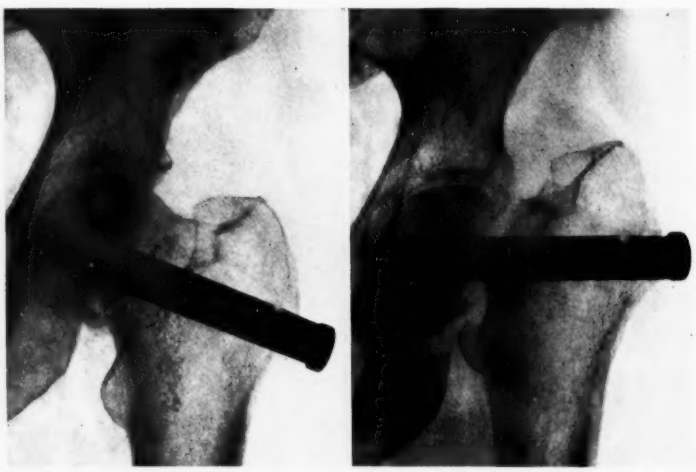

Fig. 27, left. Case 10. Roentgenogram 66 days after injury. Nailing 2 days after injury. Slightly greater density of head suggests that it is necrotic.

Fig. 28. Case 10. Thirteen and one-half months after injury. Non-union of fracture and necrotic head; reduced density in medial and inferior parts of head indicates creeping substitution of dead bone by new bone.

was treated by Whitman abduction cast for 2 months followed by bed rest for 12 weeks. A roentgenogram (Fig. 31) taken 11 months after injury showed non-union, erosion of neck fragments, and reduction in density of the hip bones except in the upper and lateral portions of the head, where the original bone density was preserved. The density of the lower part of the head was much reduced. The diagnosis was made of necrosis of the head of the femur with dead bone still retained in the dense regions. The large area of reduced density in mesial and lower portions of head suggest that some bone survived, at least about the fovea. How much of the area of decreased density is occupied by atrophic surviving bone and how much by newly formed bone that has replaced old dead bone it is difficult to say. A roentgenogram (Fig. 32) taken 2 years and 11 months after injury showed complete disappearance of the dense shadows indicative of old dead bone with replacement by a faint spongy shadow. The articular cortex casts a faint irregular shadow, and cartilage space is somewhat narrow. The irregularity of cortical shadow in the narrow cartilage space suggests death and re-organization of the entire articular cartilage. The diagnosis was made of a fracture of the neck of the femur followed by non-union, death of the head, and complete creeping substitution of the dead bone by living bone.

A Whitman reconstruction operation was performed. During excision of the head, extensive adhesions were encountered between the articular surfaces. Round ligament was buried in adhesions. The articular surface of the excised head was uneven and shaggy from adhesions. On cut section, the head consisted of spongy bone throughout, no areas being seen suggestive of remnants of necrotic tissue. Microscopic examination (Fig. 33) showed the bone to be alive and finely porous with trabeculæ irregularly arrayed. Articular cartilage was everywhere replaced by fibrocartilage, which, at a number of places was very narrow while in others it was as thick as normal articular cartilage. The articular cortex was very frail and in some places entirely lacking.

The rate of transformation in this case was more rapid than in some others of the series. One case 3 years and 8 months after injury and another 4 years after injury showed more than half of the necrotic bone still present on pathological examination of the excised heads. These two cases also showed osteocartilaginous loose bodies formed by proliferation of detached pieces of articular cartilage which were nourished by the synovial fluid. In some cases of non-union of long standing it may be impossible to state from roentgenograms whether the bone of the head survived and became atrophic or died and underwent complete replacement by new bone but the differences previously enumerated usually make it possible. Pathological examination of the head should nearly always establish the diagnosis.

Cases with non-union and necrosis of the head of very long standing and marked cartilage change are not well suited for operation intended to create bony union and a movable joint. The Whitman reconstruction operation may be followed by a bony ankylosis, as in one

Fig. 29, left. Case 11. Non-union 3 years after fracture. Necrosis in head with creeping replacement by spongy new bone, except dense island at top of head, *a*.

Fig. 30. Case 11. Bony union and dense transformation of weight bearing portion of head and shaft 1½ years after operation.

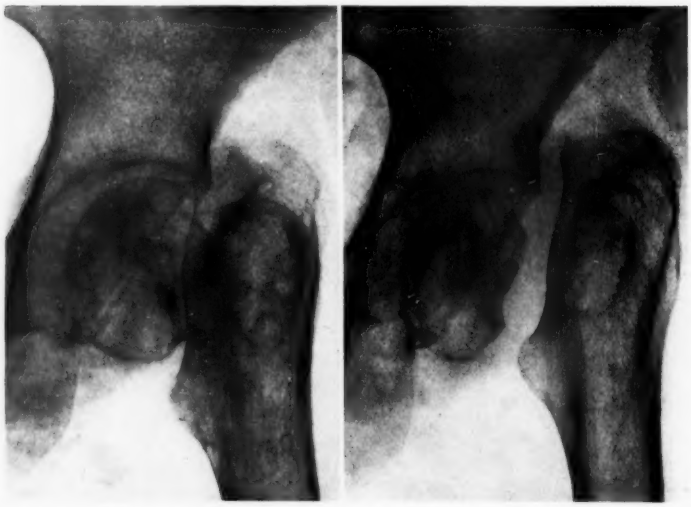

Fig. 31, left. Case 12. Non-union 11 months after fracture. Superior and part of lateral portions of head dense, indicating old dead bone; inferior and foveal regions rarefied, indicating living bone.

Fig. 32. Case 12. Two years 11 months after injury. Creeping substitution of dead portion by living bone complete. Cartilage space of joint narrowed and shadow of articular cortex incomplete.

case of the series reported elsewhere by the author (18) in which articular cartilage of acetabulum was destroyed. Operation for the creation of bony ankylosis is the procedure of choice for some of these cases.

INTRACAPSULAR FRACTURE OF THE NECK WITH DEATH OF THE HEAD FOLLOWED BY BONY UNION

Axhausen (2) was the first to call attention to this condition and his is the only reported case in which a pathological examination was made. Familiarity with the pathological and roentgenological pictures in necrosis of the femoral head and non-union makes it possible to recognize the not infrequent occurrence of necrosis of the head with bony union by the study of a series of roentgenograms taken at regular intervals. There were 4 instances in this group of 49 cases of fracture of the neck of the femur. Necrosis of the femoral head followed by bony union of the fracture has been observed most frequently in case of impaction of the fragments. But also in cases in which fragments were displaced it has followed reduction of the fracture and fixation by the Whitman abduction cast method (Case 11 of Santos) or by bone pegs or nails.

Union of the fracture is accomplished by callus formation from the distal fragment which extends across the fracture line and ossifies in much the same way as a bone graft unites with bone with which it is placed in contact. If the limb is then used the distal fragment and pelvis do not atrophy to the same extent as in cases of non-union. Consequently, the density difference between the dead portion of the head and the living bone of the region is not as marked as in cases of necrosis with non-union, and the condition is more difficult to recognize on this basis in roentgenograms than is the former. If there is too much weight bearing before the necrotic upper portion of the head is invaded and substituted by new bone there will be caving in of the weight bearing portion with marked deformity. This is illustrated by Case 13.

Case 13. Male, aged 48 years, patient of Dr Paul P. Swett, of Hartford, Connecticut, sustained an intracapsular fracture of the neck of the femur

which was treated by plaster cast immobilization. Bony union followed, and he was then allowed to walk. The hip gradually became painful and a roentgenogram (Fig. 34) taken one year after injury showed slight irregularity of cortex, flattening and subcortical increased density at the top of the head. There was irregular, increased density across the medial portion of the neck at the seat of fracture, and slight, even reduction in density in the juxtafoveal and lateral portions of the head. The density of the central and superomesial part of the head was slightly greater than that of the distal fragment. Weight bearing was continued but the hip became increasingly painful and limited in motion. A roentgenogram (Fig. 35) 1½ years after injury showed further collapse of the weight bearing portion with mottled increased and decreased density in the head beneath it. New trabeculæ were seen running perpendicularly in head and neck. There was considerable atrophy of disuse. A regional roentgenogram (Fig. 36) 6 months later showed a slight increase in density of the region and reduction in size of the area of the sequestrated head. The rest of the head appeared to be transformed. Judging by the slowness of the changes, 2 or 3 years will be required for complete absorption and reorganization of the collapsed area, and the end-result will be a marked degree of functional disturbance in the joint.

A re-examination of the 5 year old Case 11 X reported by Santos, of bony union with necrosis and collapse of the head, was made 9 years after injury. Pain and weakness had grown progressively worse and the patient had walked with a crutch for 2 years. A roentgenogram showed that the collapse and deformity of the head had slightly increased and its interior become more mottled. Two other cases of collapse of the head observed for periods of 4 to 9 years gave very poor functional results.

That a good functional result may be obtained after fracture of the neck with necrosis of the head and bony union, if collapse does not occur and creeping substitution comes about, is shown by the following instance.

Case 14. Female, aged 13 years, sustained an intracapsular fracture of the neck of the femur. A body and leg cast was applied for 6 weeks. Two months after injury a roentgenogram showed displacement and angulation of fragments, and nonunion. At operation, which showed a portion of capsule untorn, the fracture was reduced and fixed with a Smith-Peterson nail; plaster-of-paris immobilization for 10 weeks. Bony union took place, but weight bearing was not resumed until 5 months had elapsed. During this period a series of roentgenograms showed the gradual development of

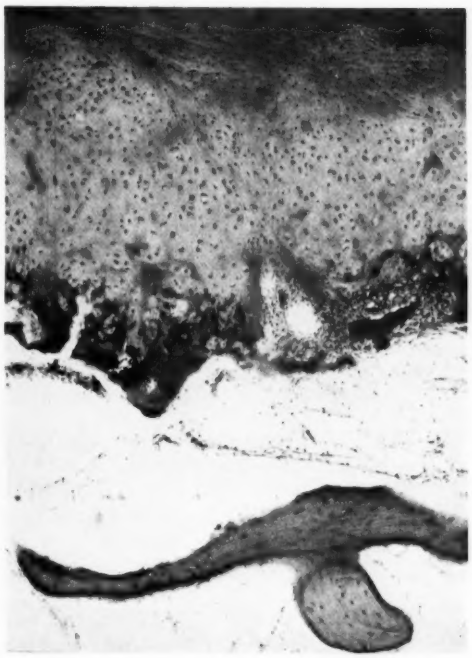

Fig. 33. Case 12. Magnification 55 diameters. Shows complete replacement of dead cartilage by fibrocartilage and dead bone by spongy new bone.

areas of reduced density progressing from neck into head, indicative of creeping substitution of a necrotic proximal fragment. Six months after injury the patient walked without pain and had three-fourths the normal range of motion in the joint. A roentgenogram (Fig. 37) showed mottling of the largely transformed head and neck. At the summit of the head the articular cortex was dense and smooth, and showed signs of incomplete sequestration at its limits, *a*. Weight bearing was continued without discomfort, and the range of motion increased gradually. Sixteen months after injury it was four-fifths normal and the joint was free from symptoms. A roentgenogram (Fig. 38) then showed a complete reconstruction of the head except at the summit, where there was a narrow dense area including articular cortex, indicative of dead bone, which was sequestrated and slightly depressed.

It would have been better to have kept the patient from weight bearing for a longer period than 5 months, since the small dead area at the summit of head was broken down before creeping replacement had had time to reach it. However, the area was so small and the rest of the head was so well trans-

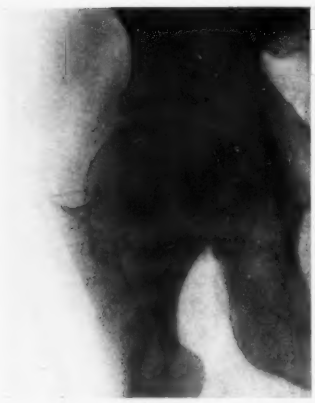

Fig. 34.

Fig. 35.

Fig. 36.

Fig. 34. Case 13. Necrotic head and bony union 1 year after intracapsular fracture of neck. Note beginning breaking down of weight bearing portion of head with dense underlying bone.

Fig. 35. Case 13. One and one-half years after injury. The roentgenogram shows further collapse of the weight bearing portion and irregular absorption and sclerosis in head.

Fig. 36. Case 13. Twenty-six months after injury. Collapsed portion dense and sequestrated; rest of head transformed. Sclerosis of zone is noticeable about collapsed portion.

formed that the defect should be repaired without loss of the excellent function that has already been obtained.

Experience with these cases has demonstrated that walking should not be allowed in case of necrosis of the head with bony union until many months have elapsed, in order to avoid fragmentation and collapse of the necrotic bone at the point of greatest pressure. No doubt too early walking has been responsible for the bad end-results in many cases. However, it is probable that despite weight bearing the dead bone does not collapse in some cases and becomes completely replaced by new bone, giving a good functional result. Such cases may be difficult to distinguish late from others in which there was union of the fractured neck with survival of the head. The mottling of the transformed dead head should, however, be sufficiently great in most cases to render its recognition possible in roentgenograms. Case 4 illustrates the difficulty in differentiation.

SLIPPING OF THE EPIPHYSIS OF THE HEAD OF THE FEMUR

The capital epiphysis of the femur not infrequently becomes separated and downwardly displaced on the neck. The condition is seen more frequently in boys than in girls and usually develops between the ages of 10 and 16. There is a definite predisposition on the part of obese individuals, and an endocrine disturbance has often been held responsible for it. It is encountered in some cases presenting Froelich's syndrome. There is often roentgenographic evidence of reduced density in the metaphysis of the neck before the slipping takes place and shortly after the onset of pain in the hip. Slight flattening of the head has also been observed before any appreciable amount of displacement is brought about. Axhausen considers these changes secondary to aseptic necrosis in the neck metaphysis from obscure vascular blockage.

Slipping of the capital epiphysis has rarely been noted before the age of 10, and in such cases necrosis with breaking down of femoral head is likely to take place. Thus, a case was observed in which there was Legg-Perthes' disease of the right hip beginning at the age of 6, followed by slight flattening of the head of the left femur, as shown incidentally in a roentgenogram taken 16 months later. Five days later the capital epiphysis of the left femur slipped markedly as a result of slight violence. After reduction and plaster cast fixation it united to neck, but necrosis and collapse of the head fol

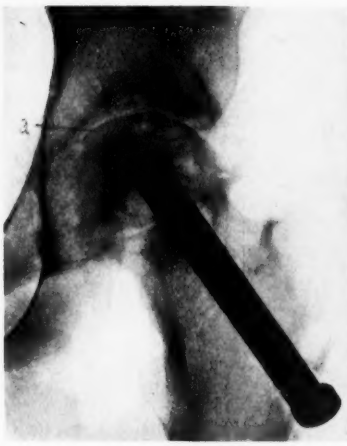

Fig. 37, left. Case 14. Six months after operation. Mottled increase and decrease in density of proximal fragment and beginning sequestration of dense summit at *a* indicate necrosis and partial creeping replacement.

Fig. 38. Case 14. Sixteen months after operation. Creeping substitution complete except for sequestrum, *a*. Good functional result.

lowed with the typical roentgen appearance of Legg-Perthes' disease on that side. This suggests strongly an etiological relationship between the two conditions.

In some cases the joint becomes painful without a history of trauma, but in the majority of cases the slipping is due to violence of variable intensity, often slight. Union nearly always takes place between head and neck even when the epiphysis is allowed to remain in marked displacement which results in growth arrest and coxa vara.

The changes in the head subsequent to slipping are variable. Slight to moderate flatten-

Fig. 39, left. Case 15. Roentgenogram immediately after slipping of capital epiphysis.

Fig. 40. Case 15. Roentgenogram 89 days after open reduction and fixation with fibular graft.

Fig. 41. Case 15. Nine years after injury. Dense area at summit of left head indicates untransformed and possibly compressed necrotic bone; rest of head collapsed and substituted by new bone. Slipped epiphysis, right, united and shows no collapse or other signs of previous necrosis.

ing and broadening is common, and the density may be uniformly reduced. Mottling is rarely seen in roentgenograms. The exact pathology of the head in such cases is not well known because of the extreme infrequency of reports of pathological examinations. It is possible that necrosis precedes slipping, but more probable that the head usually remains alive on nourishment coming through the round ligament, and changes its contour after displacement. In some cases, however, there is definite evidence of extensive necrosis, and the weight bearing portion of the head may subsequently collapse and be sequestrated, as in fracture of the neck with bony union and too early weight bearing. In such cases the slipping damages blood supply by way of capsule vessels.

Case 15. A tall, slender male, aged 16 years, fell from a bicycle and displaced the right femoral epiphysis one year previously. He was treated by plaster cast immobilization. Bony union followed with the head in moderate downward displacement. On the day of hospital admission he again fell from a bicycle and displaced the left capital epiphysis (Fig. 39). One day later the displacement was reduced by open operation and the head fixed in position by a bone peg taken from the shaft of the fibula. The neck capsule was found extensively torn. Cast immobilization. A roentgenogram (Fig. 40) 89 days later showed bony union in coxa vara position. Walking was then resumed, but the left hip subsequently remained much stiffer than the right and was slightly painful and weak on excessive usage. Figure 41 shows the condition of hips 9 years after injury to the left and 10 years after injury to the right. The left hip shows flattening of head and irregularity of articular surface of both head and acetabulum. There is a dense irregular shadow at the summit of the head which is difficult of interpretation. It might be a necrotic area or a sclerosed transformed zone as it is very dense for old necrotic bone and shows no line of separation from the surrounding spongy bone. If it is dead bone, the period of creeping replacement has been unusually slow. If it is sequestrated there has been marked retardation of the process of removal of the dead bone. The narrow cartilage space of the joint indicates destruction of articular cartilage.

Fig. 42.

Fig. 43.

Fig. 44.

Fig. 42. Case 16. Three years after fracture of base of neck. Head broken down in weight bearing portion and outline of cortex irregular and distorted; neck mottled and dense; changes indicate necrosis with creeping replacement.

Fig. 43. Case 17. Female aged 12, recent fracture of greater trochanter.

Fig. 44. Case 17. Six and one-half years after injury. Dense area at summit of head indicates necrotic bone; collapse of top of head and irregular creeping substitution of remaining portions; top of neck irregular; necrosis apparently due to injury of superior neck vessel at time of fracture.

The bad end-result must be attributed to necrosis of the head with collapse before there was creeping replacement by new bone. The operative reduction and fixation were probably factors in producing the necrosis. Much better anatomical and functional results were obtained in the right hip, which shows healing with moderate coxa vara. That head does not appear to have undergone necrosis and the cartilage space of the joint is preserved.

FRACTURE OF THE BASE OF THE NECK OF THE FEMUR

It has been generally considered that fractures at the base of the neck of the femur do not interfere with the blood supply of the head and neck. Roentgenological studies have shown, however, that necrosis may occur, although rarely. Lange (11) has reported 2 cases, and there was one instance in this group.

Case 16. Female, aged 17 years, sustained a fracture at the base of the neck 2 years and 5 months before admission. She was treated by extension for 5 weeks and a plaster cast for 4 weeks. Bony union resulted with head and neck at a right angle to the shaft. Walking was resumed, but the hip gradually became painful and motion was limited. A roentgenogram at the time of admission (Fig. 42) showed the head and neck united to the shaft at an angle of 90 degrees. The head was broken down and irregular in its weight bearing portion, as if necrosis followed by creeping substitution had taken place. A subtrochanteric osteotomy was performed and union obtained with the shaft in abduction.

In case of fracture at the base of the neck with displacement and tearing of the capsule, it is possible that the posterior cervical vessels may be torn, and in case the collateral circulation through the round ligament is insufficient partial necrosis would be the inevitable result.

NECROSIS OF FEMORAL HEAD FOLLOWING FRACTURE OF THE GREATER TROCHANTER

The observation of roentgenographic signs of necrosis of the femoral head after fracture of the greater trochanter in the following case has raised the question as to the etiological relationship.

Case 17. Female, aged 12 years, a patient of Dr. E. L. Mason of Eau Claire, Wisconsin, sustained a fracture of the greater trochanter of the left femur in an automobile accident (Fig. 43). The fracture healed and the patient was free from symptoms for 4 years. She then began to have limitation of motion and pain in the hip joint on walking, which slowly increased.

A roentgenogram (Fig. 44) taken 6½ years after injury showed evidence of extensive degenerative and absorptive changes in the head of the femur. There was irregular flattening of the lateral half of

Fig. 45.

Fig. 46.

Fig. 47.

Fig. 45. Case 18. Fresh fracture of acetabulum and dislocation of hip.

Fig. 46. Case 18. Eleven months after injury. Dense area represents necrosis at summit of head, *a*.

Fig. 47. Case 18. This roentgenogram was taken 19 months after injury and shows creeping replacement of the dense necrotic area by blotchy new bone; with little collapse of head.

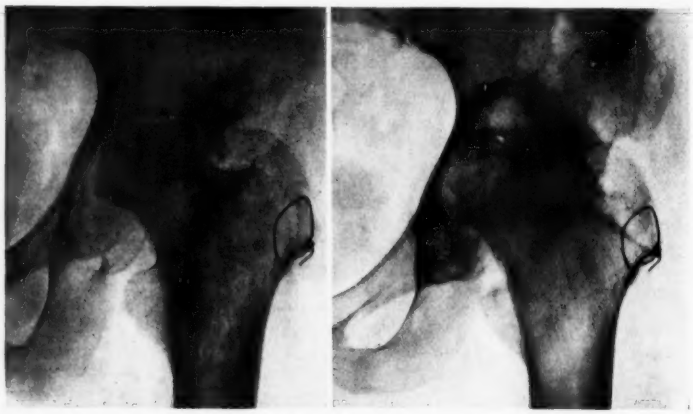

Fig. 48, left. Necrosis of head and part of neck 5 months after arthroplasty. The head retains its old density and surrounding living bone is atrophied.
Fig. 49. Two years 8 months after Figure 48. Necrotic head partly eroded and partly substituted by ingrowth from neck. Joint space irregular and narrow.

the top of the head with mottled areas of reduced and increased densities in the underlying portion down to the neck. At the summit of the head was a uniformly dense area with a smooth articular cortex and irregular outlines similar to that seen in Figure 41. The density of the head, mesial and inferior to this, was greatly reduced and more uniform in outline. There was a slight irregularity of trabeculæ in the top of the neck and one area of reduced density suggesting a cavity. The acetabulum showed no change except for a slight lipping at its superior margin.

The diagnosis was made of aseptic necrosis with breaking down and partial substitution of the head of the femur. The only known factor to which it could be attributed was the fracture of the greater trochanter. The superior neck vessel supplying a portion of neck and head might easily have been injured and an inadequate collateral circulation would have resulted in death of the region which it supplied. The late appearance of symptoms is somewhat against this explanation. However, the very slow rate of change sometimes observed in the necrotic head after fracture of the neck as shown in Figure 26, 16 months after injury, or Figure 41, 9 years after injury, would favor the view that the fracture of the trochanter injuring the blood supply was the cause of the necrosis in this patient. A walking caliper splint was applied which considerably reduced the amount of pain; but a roentgenogram taken 1 year later showed only slight increase in the reconstruction of the head.

No case of injury of this type, followed by necrosis, could be found in a search of the literature.

TRAUMATIC DISLOCATION OF THE HIP FOLLOWED BY NECROSIS OF THE HEAD OF THE FEMUR

In traumatic dislocation of the hip the ligamentum teres is always torn. In case the vessels passing through it are of importance for the blood supply of the femoral head, necrosis of bone would be expected unless the collateral circulation from the neck vessels is sufficient to keep it alive. In the past almost no consideration has been given to this possibility.

Chandler and Kreuscher recently reported a case of necrosis in the head of the femur following fracture of the acetabulum with dislocation of the hip; Stewart reported the same condition following a simple posterior dislocation of the hip, from this department.

Four instances of necrosis of the head of the femur following dislocation of the hip have been observed in these studies; three following simple dislocation and one following fracture through the acetabulum with dislocation. Judging from these observations, the condition is of importance in the causation of poor end-results in traumatic dislocation. In 2 cases, 1 reported by Stewart, the head gradually collapsed in its weight bearing portion. In an 11 year old boy, a patient of Dr. Frank Dickson, the head flattened moderately and showed mottled areas of increased and de-

creased density somewhat similar to Legg-Perthes' disease. In the following case the dead part of the head became transformed with only slight flattening.

CASE 18. Female, aged 14, patient of Dr. Otto T. Roberg, sustained a fracture of the acetabulum with posterior dislocation of the hip as seen in a roentgenogram (Fig. 45) taken immediately afterward. The dislocation was reduced and the hip treated by plaster-of-paris immobilization and extension for 6 weeks. Roentgenograms showed signs of healing of the fracture, and the head within acetabulum showed no changes in contour or density. Walking was allowed after 4 months. Slight stiffness and pain persisted in the hip and a roentgenogram taken 11 months after the injury showed a dense oval shadow occupying the summit of the head of the femur with irregular reduction in density, suggesting cavities in the head, below and about the dense area (Fig. 46). The shadows of articular cortex, both mesial and lateral to it, were irregular and reduced in density.

A diagnosis was made of necrosis of most of the head of the femur from injury of blood supply by way of the round ligament, with persistence of a dense area of necrosis at the summit and irregular creeping replacement of the deeper necrotic portions with very slight flattening of the head.

Subsequent roentgenograms showed gradual reduction in size of the necrotic portion, and one taken 19 months after injury (Fig. 47) showed almost complete disappearance of the dense shadow indicative of dead bone, with little change of contour of femoral head and a motley shadow in the subcortical region, especially of the weight bearing portion. There was a lateral marginal lipping of the head. The functional result 2⅓ years after injury was good.

The case shows the importance of avoiding collapse while creeping substitution of dead by living bone is going on. Despite the fact that the creeping substitution without collapse occurred here in the presence of weight bearing, it is a safer procedure during the transformative period to keep the patient on crutches or at least in a weight bearing caliper splint.

A study of the end-results of a large series of traumatic dislocations of the hip is greatly needed in order to learn the frequency of necrosis of the femoral head and the extent of disability which it produces.

CONGENITAL DISLOCATION OF HIP

Collapse of the head of the femur and absorptive and proliferative changes similar to Legg-Perthes' disease are well known following either manipulative or operative reduction of congenital dislocation of the hip, as reported by Legg and Allison. The condition is most frequently attributed to injury of the blood supply coming through the round ligament. It may result either from compression of the elongated round ligament between the reduced head and acetabulum or, in some instances, from tearing. Excision of the round ligament as has sometimes been practiced in open reduction should increase the incidence of necrosis of the head and should be avoided.

Pathological dislocation of the hip complicating acute pyogenic arthritis with effusion is a not uncommon occurrence and leads to severance of the round ligament. In some cases the head becomes necrotic in which event it may be difficult to distinguish the changes resulting from cutting off of circulation from those resulting from the infection.

A boy, aged 7 years, had osteomyelitis of the proximal end of the shaft of the femur with suppurative arthritis and dislocation of the hip, which was reduced by open operation, at which time the round ligament was found severed. Subsequent roentgenograms showed a dense head indicating necrosis which was followed by partial breaking down and almost complete ankylosis of the hip.

A second case shows that it does not always happen.

A male, aged 9 years, with acute hæmatogenous arthritis of the hip complicating staphylococcus osteomyelitis of astragalus; the hip joint became dislocated. It was reduced. Subsequent roentgenograms, the last being 14 years afterward, showed no evidence of capital necrosis, and function was restored to normal.

NECROSIS OF FEMORAL HEAD FOLLOWING ARTHROPLASTY FOR ANKYLOSIS OF HIP

In the operation of mobilization of an ankylosed hip, not only is the bony connection between head and acetabulum severed, but also the capsule of the neck is usually stripped in the delivery of head and neck. This may interfere with the blood supply sufficiently to cause necrosis of a part or all of the head, in which event the result of the operation is usually a poor one. The hip may remain painful and its range of motion be limited. Marked regional atrophy of disuse may develop in the pelvis and shaft of the femur, while the dead

bone does not atrophy. As a result, the necrotic portion may be distinguished in roentgenograms after a few weeks, because it casts a heavier shadow than the surrounding living bone. The dead portion is gradually eroded from the joint side, reducing it in volume. It is also invaded from the neck side by connective tissue which brings about absorption and more or less complete creeping replacement by new bone. The erosion may proceed more rapidly than the creeping replacement when the head may be greatly reduced in size.

Two cases of capital necrosis following arthroplasty have been observed in this study; in one case previously reported the entire head became necrotic, as shown in Figure 48, 5 months after operation. Roentgenograms made since the report and 2 years and 8 months after operation (Fig. 49) show the head reduced in size and density. The hip continued painful and motion was very limited.

In a second case, a female, aged 34 years, had primary healing of the operative wound, but the upper portion of the head became necrotic and was gradually destroyed by erosion, there being very little creeping replacement. Two years and 8 months later the head was reduced to about one-fourth its original size, and although the hip was freely movable, it tolerated weight bearing poorly.

CIRCULATORY DISTURBANCES OF MORE OBSCURE NATURE

A discussion of necrosis in the head of the femur from known traumatic causes would be incomplete without at least a brief consideration of Legg-Perthes' disease, death with collapse and separation, partial or complete, of a portion of the head in adults and osteochondritis dessicans.

In Legg-Perthes' disease the lesion is essentially a necrosis, which is usually confined to the head of the femur, but not infrequently there are changes of an absorptive nature in the lateral portion of the metaphysis of the neck which suggest that they are also preceded by necrosis in that region. The necrosis in the head is followed by bone absorption and flattening. In some cases a portion of the dead bone may be sequestrated by fragmentation of the trabeculæ at the line of junction with ingrowing new bone. In other cases the dead bone seems to be compressed, and casts a shadow in roentgenograms that is heavier than normal bone. Regeneration of the bone of the head comes about by vascular and fibrous invasion of the necrotic area with new bone formation and replacement partly after complete absorption and partly by creeping substitution. An exuberant fibroblastic reaction with excessive absorption of dead bone is sometimes seen which is in excess of anything seen in aseptic necrosis caused by fractures, and raises the question of whether some additional factor, as infection, is not active.

The necrosis is the result of a disturbance in the circulation, but the cause of the circulatory disturbance is as yet imperfectly understood. It has been considered as due to injury to the blood vessels without associated fracture or dislocation of the hip. In many cases there is much in favor of this view as the lesion follows weeks or months after a trauma of considerable magnitude. The late appearance of symptoms in some cases might be understandable in view of the lateness of symptoms in cases of necrosis following hip dislocation and fracture. When the head only is necrotic, the injury might be of the round ligament. In case of changes in the head, accompanied by extensive absorption in the superior and mesial portion of the neck, it is difficult to explain the condition on the basis of a trauma to the blood vessels. Disturbance of the superior neck artery might in some cases result in necrosis and absorption in both the head and the superior portion of the neck, but this would scarcely result from trauma without fracture. Also there are many cases in which there is no history of trauma and the condition is frequently bilateral, which is also a point against a purely traumatic etiology.

Disease involving and obstructing the blood vessel has been considered as a cause. Axhausen has considered the possibility of embolism. However, this theory is not well supported on anatomical grounds. Arteritis such as occurs in rheumatic fever with obliteration of the vessel as described by Von Glahn and Pappenheimer has been considered as a possible cause by Phemister, Brunschwig, and Day. Streptococcus viridans has grown in cul-

tures of biopsies in a few instances, but in the great majority of cases cultures of biopsies have remained sterile, and it seems very improbable that bacterial action is the primary cause, at least in the great majority of cases. Seeding of bacteria in the field after occurrence of the necrosis may possibly explain some of the positive bacterial findings. Further studies will be necessary to clarify the nature of the disease.

Large areas of aseptic necrosis have been observed in the head of the femur in adults in which no adequate cause could be elicited. Freund reported the autopsy findings in the case of a 77 year old woman who had been bedridden for 2 years, with lame hips. In the right hip there was a large area of necrosis with collapse at the top of the femur and in the left hip a similar collapsed area in the mesial portion of head extending outward from the fovea. In some areas there was separation of the dead bone from the living resulting from fragmentation of trabeculæ. In others there was fibrous invasion and creeping substitution of the dead bone. The overlying articular cartilage was necrotic, folded, and partly absorbed. Injury or embolism of the right superior neck vessel and of the left ligamentum teres artery might have produced the lesions. Schmorl (20) and Kraft have published accounts of similar lesions, and Chandler reported a case studied pathologically of extensive aseptic necrosis with sequestration extending lateral and superior to the fovea capitis, which he considered due to embolism. Weight bearing has usually caused a certain amount of collapse or sequestration in these cases with resultant pain, stiffness, and permanent disability of the joint.

A few instances as those of Lange (10) of osteochondritis dessicans of the femoral head are recorded in which a portion of bone and articular cartilage has become necrotic and detached as loose bodies in the hip joint. The etiology is obscure but possibly it is the same as that of the larger areas of aseptic necrosis in adults that do not become detached and dislodged from their beds.

SUMMARY

Intracapsular fracture of the neck of the femur may, by injury of blood supply, result in aseptic necrosis of a part or all of the head of the femur. This occurrence greatly increases the likelihood of non-union of the fracture as shown by the statistics herein reported. Articular cartilage very slowly dies if the bone to which it is attached becomes necrotic. In case of non-union, atrophy of disuse of the living bone develops during the period of immobilization while the dead bone of the head does not atrophy. Consequently after 2 to 3 months, it can usually be diagnosed in roentgenograms because its density is greater than that of the surrounding living bone. Connective tissue and blood vessels slowly invade the dead bone which in turn is absorbed and replaced by new bone by the process of creeping substitution. Months or years may be required for completion of the change. Necrotic cartilage is absorbed after a long interval and replaced by either fibrocartilage or connective tissue.

In case of necrosis in the head of the femur and bony union of the fracture, the necrotic area also becomes replaced by new bone if the dead bone is protected from too great weight bearing during the period of transformation. If it is used too much in weight bearing, the upper portion of head may collapse from the giving way of the dead bony trabeculæ and a bad deformity and functional result be obtained.

Intracapsular fracture of the neck with survival of the head and either union or non-union of the fracture may be diagnosed in roentgenograms by the uniformity of reduction in density in pelvis, head, and distal fragment at all stages in the course of the injury. Bony union is followed by a good functional result, but late degenerative arthritis occasionally develops. Non-union is more amenable to operative treatment if the head remains alive than if it becomes necrotic.

Slipped femoral epiphyses during adolescence or late childhood may result in aseptic necrosis followed by collapse and extensive deformity of the head as a result presumably of injury to blood vessels entering it by way of the neck.

One case each is reported of necrosis and collapse of the head of the femur following fracture of the base of the neck with bony union and fracture of the greater trochanter.

Traumatic dislocation of the hip always severs the round ligament, which in some cases contains blood vessels supplying a portion of the head of the femur. Aseptic necrosis of this area results unless there is adequate collateral circulation from the neck vessels. Four such cases have been observed. Creeping substitution of the dead bone by new bone ensues. Too extensive weight bearing before the transformation is complete may result in collapse of the head and permanent lameness of the hip.

Congenital dislocations of the hip that are reduced by manipulation or operation and pathological dislocations of the hip may show signs of necrosis and breaking down of the femoral head due to damage of circulation by way of the round ligament.

Arthroplasty for the mobilization of ankylosed hips resulted in aseptic necrosis of the head of the femur in 2 cases with poor functional results.

Aseptic necrosis in the head of the femur of obscure origin is seen in Perthes' disease, in osteochondritis dessicans, and in adults in which there is no history of an etiological factor. The essential change appears to be an interference with circulation. Causative factors that have been considered are trauma, embolism, obliterative vascular disease with or without an associated mild infection, and constitutional and endocrine disturbances, but no single factor offers an adequate explanation for the picture.

The bearing of aseptic necrosis on the treatment of fractures of the neck of the femur and hip dislocations is discussed.

REFERENCES

1. Allison, N. The adaptive changes in the hip in congenital dislocation and their importance in treatment. J. Bone & Joint Surg., 1928, x, 687–695.
2. Axhausen, G. Die Nekrose des proximalen Bruchstuechs beim Schenkalhalsbruch und ihre Bedeutung fuer das Hueftgelenk. Arch. f. klin. Chir., 1922, cxx, 325.
3. Idem. Ueber anaemische Infarkte am Knochensystem und ihre Bedeutung fuer die Lehre von den primaeren Epiphyseonekrosen. Arch. f. klin. Chir., 1928, cli, 72.
4. Bonn, R. Zur Frage der knoechernen Heilung subkapitaler Schenkelhalsfrakturen. Arch. f. klin. Chir., 1925, cxxxiv, 270.
5. Chandler, S. B., and Kreuscher, P. H. A study of the blood supply of the ligamentum teres, etc. J. Bone & Joint Surg., 1932, xvi, 834.
6. Freund, E. Zur Frage der aseptischen Knochen nekrose. Arch. f. path. Anat., 1926, cclxi, 1.
7. Hesse, F. Zur pathologischen Anatomie der Schenkelhalsfrakturen. Arch. f. klin. Chir., 1925, cxxxiv, 141.
8. Keefer, Chester S., and Myers, Walter K. The incidence and pathogenesis of degenerative arthritis. J. Am. M. Ass., 1934, cii, 811.
9. Kraft. Zur traumatischen Grundlage der osteochondritis coxae juvenilis deformans. Deutsche Ztschr. f. Chir., 1931, ccxxxiii, 23.
10. Lange, M. Zwei Faelle von doppelseitiger Osteochondritis dessicans (Konig) der Femurkoepfe. Ztschr. f. orthop. Chir., 1929, li.
11. Idem. Die Gefahr der Pseudarthrosenbildung und Femurkopfnekrose nach Schenkelhals und Schenkelkopf bruechen Jugentlicher. Ztschr. f. orthop. Chir., 1933, lvii, 530.
12. Langer, C. Ueber das Gefaess-system der Rohren knochen. Denkschr. d. k. Akad. d. Wissensch. Math.-naturw. klasse Wien., 1865, xxxvi, 757.
13. Legg, A. T. Osteochondral trophopathy of the hip-joint. Surg., Gynec. & Obst., 1916, xxii, 307.
14. Lexer, F. Die Entstehung entzuendlicher Knochenherde und ihr Beziehung zu den Arterienverzweigungen der Knochen. Arch. f. klin. Chir., 1903, lii, Ebend Bd. 71, S 1; Weitere Untersuchungen ueber Knochenarterien und ihrer Bedeutung fuer krankhafte Vorgaenge. Deutsche Ztschr. f. Chir., 1904, xliii, 481.
15. Nussbaum, A. Die arteriellen Gefaesse der Epiphysen des Oberschenkels und ihre Beziehungen zu normalen und pathologischen Vorgaengen. Beitr. z. klin. Chir., 1923–1924, cxxx, 495.
16. Idem. Die Gefaesse am oberen Femurende und ihre Beziehungen zu pathologischen Prozessen. Beitr. z. klin. Chir., 1926, cxxxvii, 332.
17. Phemister, D. B., Brunschwig, Alexander, and Day, Lois. Streptococcal infections of the epiphyses and short bones. J. Am. M. Ass., 1930, xcv, 995.
18. Phemister, D. B. Repair of bone in the presence of aseptic necrosis resulting from fractures, transplantations, and vascular obstruction. J. Bone & Joint Surg., 1930, xii, 769–787; Aseptische Knochennekrose bei Frakturen, Transplantationen und Gefaessverschluessen. Ztschr. f. orthop. Chir., 1931, lv.
19. Santos, Jose V. Changes in the head of the femur after complete intracapsular fracture of the neck. Arch. Surg., 1930, xxi, 470–530.
20. Schmorl, G. Anaemische Nekrose im Schenkelkopf. Zentralbl. f. allg. Path. u. path. Anat., 1924, xxxv.
21. Idem. Die pathologische Anatomie der Schenkelhalsfraktur. Muenchen. med. Wchnschr., 1924, xl, 1381.
22. Schulze, W. Ueber die Ursachen der Bakterienablagerung im Knochen. Arch. f. klin. Chir., 1933, clxxvii, 450.
23. Stewart, William J. Aseptic necrosis of the head of the femur following traumatic dislocation of the hip joint. J. Bone & Joint Surg., 1933, xv, 413–438.
24. Von Glahn, W. C., and Pappenheimer, A. M. Rheumatic disease of auricle and blood vessels. Tr. Ass. Am. Physicians, 1928, p. 203.
25. Wollenberg. Experimentelle Ernaehrungsstoerungen am Knochen. Verhandl. 21. Kongr. deutsch. orthop. Gesellsch. Ueber Knochennekrose. Ztschr. f. orthop. Chir., l.
26. Zemansky, A. P., Jr., and Lippmann, R. K. The importance of the vessels in the round ligament to the head of the femur during the period of growth, etc. Surg., Gynec. & Obst., 1929, xlviii, 461.

TUMORS OF THE TENDON SHEATHS

Their Close Biological Relationship to Tumors of the Joints and Bursæ

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UPON an occasion such as this, it seems but fitting to present a study of some phase of tendon surgery. Dr. Allen Kanavel and his pupils have so well and so completely covered the infections in their relationship to later functional use, that there is very little left to add to this subject. The tumors of the tendon sheaths, aside from the xanthomatic giant cell tumors so well described by Mason and Woolston of Kanavel's clinic in 1927, offer a more fertile field for investigation. The cases which have been reported in the literature, although quite numerous, offer such a diversity of pathological types that it is with considerable trepidation that a surgeon rushes in where pathologists fear to tread. Reports on tendon sheath tumors may in fact be said to be in exactly the same position as the tumors of bone were 15 years ago. Descriptive adjectives regarding the types of cells noted in these tumors have been used to set up clinical entities. If consideration were given to the biological origin of these tumors and the descriptive adjectives reserved for definition of the characteristics of the tumor, a real advance might be made in getting a more uniform nomenclature. With such a point of view, the writer, after reviewing the material from the University of Rochester clinic, hesitatingly offers a tentative classification. A study of the tumors of joints and bursæ should be included to make this classification complete. This paper will be limited, however, to the tumors of the tendon sheaths. The tumors of the joints and bursæ will be reported in a later publication.

Case 1. A. J., No. 203, a woman, 40 years of age, came into the surgical clinic on August 22, 1931, for the removal of a small tumor on the right thumb. There was a growth the size of a pea present on the extensor tendon of the thumb near the interphalangeal joint. It did not cause any pain and removal was for cosmetic reasons only. Under local anæsthesia the tumor was dissected free from the extensor tendon sheath where the sheath expanded into the capsule of the interphalangeal joint. Macroscopic examination showed a hard nodule of yellowish tissue 4 millimeters in diameter. There was a thin fibrous capsule about it. Microscopically, there was a diffuse infiltration of large mononuclear cells and giant cells into the fibrous tissue which comprised the bulk of the section. The giant cells had centrally arranged round, oval, or angle-shaped nuclei. In many areas there were brown pigmented granules—some of which were phagocyted by round cells (Fig. 1). Diagnosis: giant cell fibroma of tendon sheaths. There had been no return of the growth on examination 2 years later.

Case 2. J. B., No. 33164, a man, 65 years of age, was seen on August 21, 1930, in the surgical out patient department because of a tumor on the flexor surface of the left ring finger. This tumor was firm, about 1 centimeter in diameter and showed some evidence of inflammation, possibly a low grade infection. It was removed under local anæsthesia, but all of it could not be excised because it involved periosteum as well as flexor tendon sheath. Microscopic section showed dense fibrous tissue with many giant cells. The nuclei were scattered all through these giant cells and were not confined to periphery (Fig. 2). Diagnosis: giant cell fibroma. The wound became infected and it was almost 1 month before healing occurred. The patient has not reported to the hospital since October, 1930. At that time the wound had healed without evidence of recurrence.

Case 3. A. S., No. 6629, a woman aged 63 years, was admitted to the surgical out patient department on April 13, 1927. She had noticed a swelling on the dorsum of the terminal phalanx of the left middle finger for about 2 years. Six months ago a second similar lesion appeared more proximal to the original growth. There has been no pain or tenderness associated with these swellings. On examination, there was found a rounded swelling 1 centimeter in diameter on the radial side of the distal phalanx of the middle finger of the left hand. This swelling was firm, not attached to the bone, and did not fluctuate. The skin over it was movable but it seemed anchored to the tendon. A smaller, similar lesion was present more proximal to the swelling described. Roentgen-ray examination showed no bone involvement (Fig. 3). Under local anæsthesia both masses were removed. They were attached to the extensor tendon and were well encapsulated. These tumors were described as fibrous with here and there calcified areas. No microscopic examination was recorded. The wound healed well, and the patient did not appear again until June 25, 1929, when she complained of two lumps on her finger in the same place as be-

fore. These tumors were again removed under local anæsthesia. They were attached to the extensor tendon and were encapsulated. In the gross, the larger nodule appeared fibrous on section. It measured three-fourths centimeter in diameter. Microscopically, there were many cells growing in an aimless and disorganized fashion suggesting a sarcoma. There were many spindle and polyhedral cells. The polyhedral cells had globules and yellowish granules in their cytoplasm—xanthomatous foam cells. Some of the spindle cells contained yellow pigment. There were also present a great number of multinuclear giant cells the nuclei of which were for the most part central. There was considerable blood pigment present in the tissue and in the foam cells (Fig. 4). Healing was prompt following operation. The patient has not been seen since September 5, 1929. Diagnosis: xanthomatous giant cell tumor of the tendon sheath.

Case 4. H. M., No. 83677, a man, aged 21 years, was admitted to the Strong Memorial Hospital on May 31, 1934. About 5 years ago he noticed a swelling on the back of the left hand over the middle portion of the wrist joint. One year ago a tumor appeared on the palmar surface of the left hand at the base of the ring finger. Both tumors have slowly increased in size and now cause interference with his piano playing. Examination revealed normal conditions except for the tumors on the left hand. There was a rounded, fluctuant, non-tender tumor 2.5 by 2.0 by 1.0 centimeters in diameter beneath the extensor tendons at the distal carpal line. It was not fixed to the skin and occupied the mid dorsum of the wrist. The other tumor was situated in the web of the fourth and fifth fingers on the palmar surface of the left hand. It measured 1 by 1 by 1 centimeters. It seemed to be attached to the sheath of the superficial flexor tendon of the fourth finger. It was firm and slightly tender on palpation. The laboratory findings were normal. At operation, under nitrous oxide oxygen anæsthesia, the dorsal tumor was found to have its origin in ligaments of the wrist joint from which it was excised. The palmar tumor was attached to the flexor tendon sheath of the fourth finger and extended through within the sheath by a small finger-like prolongation for a distance of 1 centimeter. It was smooth, rounded, about 1 centimeter in diameter and had a mottled yellowish brown color. Microscopic examination of the dorsal tumor showed a cyst-like structure with a thick wall of connective tissue cells. Occasional round cells were observed in the wall. The tumor from the palmar surface of the hand consisted of dense fibrous stroma made up essentially of fibroblasts. Numerous giant cells were present, also phagocytes containing brown pigment. There were also masses of large xanthoma cells (Fig. 5). Diagnosis: xanthomatous giant cell tumor of flexor tendon of fourth finger; "ganglion," from capsule of wrist joint.

Case 5. K. T., No. 38090, a boy, aged 19 years, was admitted to the Strong Memorial Hospital on August 26, 1930. Eighteen months ago, he first noticed a lump on the lateral surface of the dorsum of his right foot. This lump has slowly grown larger. There has been no pain except the discomfort from the pressure of his shoe. There has been occasional aching in the calf of the leg. Two years ago he had a small fracture in this same region, and he believes that the tumor may have started from this. His past history was essentially negative. General physical examination was normal. There was an egg sized, non-tender, subcutaneous, slightly movable tumor in the metatarsal region on the dorsolateral aspect of the right foot. It felt elastic and, although the skin over it was freely movable, the tumor seemed attached to the deeper structures. There were no signs of inflammation. The vital signs and laboratory examinations were normal. Roentgen ray showed atrophy of the outer side of the right cuboid and of the proximal end of the fifth metatarsal. There was a soft tissue swelling, uniform in density, with sharp outline and no calcium deposits in it (Fig. 6). Under spinal anæsthesia the tumor was exposed. It surrounded the peroneus brevis muscle near its point of insertion. The tumor was yellowish, granular in appearance, with streaks of denser yellow tissue. It was firm and encapsulated, there being no evidence of invasion of the soft tissues or of the contiguous atrophied bones. The peroneus longus was easily separated from it. The tendon of the peroneus brevis was cut 2.5 centimeters proximal to the tumor and the bone chipped off distally so that the end of the tendon and the tumor was removed intact. The mass measured 6 by 5 by 2 centimeters and weighed 24 grams. On cut section the surface was greyish yellow with deeper yellow streaks. Microscopically there was an abundant connective tissue stroma and bands of fibrous tissue running throughout. There were irregular shaped giant cells with nuclei arranged centrally, peripherally, and in clumps at the ends. There were many areas of cholesterin crystals surrounding which were seen xanthochromic foam cells. There were some areas of hæmorrhage, degeneration, and signs of chronic inflammation (Fig. 7). Diagnosis: xanthomatous giant cell tumor of the tendon sheath of the right peroneus brevis. Convalescence was uneventful. He was discharged on September 4, 1930. There has been no further trouble to date.

Case 6. M. S., No. 51026, a woman, 24 years of age, was admitted to the Rochester Municipal Hospital on April 4, 1933. She began to have backache and lower abdominal pain in December, 1932, following a dilatation and curettage. Treatment in the physiotheraphy clinic was instituted without improvement. In February, 1933, pain radiated down her right leg in addition to her other symptoms. About 2 weeks later a thickening in the tendo achillis on each side was noted. Stretching of these tendons caused pain more marked on the left side. Conservative orthopedic measures were instituted without relief. It was decided to explore the tendons but sudden development of pain in both shoulders and

wrists directed attention to removal of possible foci of infection. Accordingly, the tonsils and several teeth were removed. Careful examination showed nothing of importance related to the swellings of the heel cords. There were no patches of xanthelasma on the skin and the laboratory examinations were all normal. Exploration of the tendons was carried out on May 3, 1933, under nitrous oxide anæsthesia. The sheath of the right Achilles tendon had numerous deposits in it which were yellowish ochre in color. On splitting the sheath the tendon itself was found to be about three times the normal size. It was grossly irregular and on palpation numerous nodules were felt throughout its course. The fibers were separated, thus exposing numerous hard lemon yellow tumors scattered between the tendinous fibers. The tumors extended all the way to the insertion of the tendon and almost to the junction with the muscles (Fig. 8). The left tendon presented a picture which was almost identical. Not having any precedent for the treatment of this condition it was decided to pare down the tendons to their proper size, and to restore the sheaths. Accordingly, this was done. She made a good recovery and was discharged to the orthopedic clinic on May 15, 1933. Microscopic sections showed tendon fibers which were separated by areas of invasive fibrous tissue. The connective tissue fibers were young and were accompanied by numerous mononuclears and giant cells. The tissue was fairly vascular and had the appearance of chronic granulation tissue. Fat stains revealed many lipochrome granules in the tumor cells. The relation of tumor tissue to tendon fibers in the sections was about equally divided. A diagnosis was made of xanthoma of the tendon sheaths and infiltration with xanthomatous tissue of the tendons themselves (Figs. 9 and 10).

During the summer, she became progressively more disabled as the tendons again increased in size. A course of roentgen-ray treatments of 450 r strength were given over the tendons until a total r dosage of 2300 was reached. There was no appreciable effect from this. It was finally decided that nothing would succeed short of a radical excision of the whole Achilles tendon with reconstruction of a new tendon out of fascia lata. When she entered the hospital for this operation on October 17, 1933, there were tender indurated nodules 1 to 2 centimeters in diameter along both Achilles tendons. On the left side these extended for 22 centimeters upward and on the right side for 14 centimeters. Dorsiflexion was limited by pain on both sides at 110 degrees. Laboratory studies were normal. Resection of the right tendon with reconstruction was done on October 18, 1933. A plaster cast was applied and not removed till November 21, 1933. At that time the wound was well healed; there was no evidence of recurrence and the grafted tendon appeared to function. Physiotherapy was started. An operation similar to that of October 18 was carried out on the left side on November 29, 1933. She has had a long slow convalescence and has practically had to relearn how to balance herself before resuming her walking. She now (March, 1934) gets about without crutches but has not yet resumed her normal gait. There has been no sign of recurrence of the xanthomatous condition. Sections of the excised tendons were exceedingly hard to cut but showed essentially the same picture as the original sections. This patient offered definite problems in orthopedic and plastic surgery, and her history is being reported in detail by Drs. Young and Harris.

CASE 7. E. N., No. 40340, a girl of 14 years, was admitted to the Rochester Municipal Hospital for acute nasopharyngitis on October 29, 1930. While in the hospital a nodule about 2 centimeters in diameter was discovered at the insertion of the right tendo achillis. She said that it had been there several years and had not caused any discomfort. Examination showed that there was a slightly movable, non-tender, subcutaneous nodule attached to the tissues at the insertion of the tendo achillis. The mass was soft in consistency with two central, rounded, somewhat cartilaginous bodies. Under nitrous oxide oxygen anæsthesia the tumor was exposed. It was situated directly upon the posterior sheath of the distal end of the tendo achillis. It was not firmly adherent and was easily stripped off. It consisted of two firm, whitish, fibrous nodules. On microscopic section the tumor was composed mainly of moderately vascular connective tissue. The vessels were somewhat thickened and there were areas suggesting degeneration (Fig. 11). Diagnosis: degenerated fibroma. She was discharged after an uneventful recovery. On May 9, 1931, there was no evidence of recurrence. She has not been examined since.

CASE 8. A. S., No. 72052, a woman, aged 58 years, was studied in the medical out patient department for indigestion. On physical examination a tumor was discovered just above the right ankle joint. She said that it had been there for 15 years but had not caused any trouble until 1 year ago. At that time it became tender and increased in size. On examination a tumor measuring 2 by 2 centimeters was noted just above the ankle joint and on the medial side of the anterior tibial tendon. It was firm, ovoid in shape, very tender, and attached to the tendon or its sheath but freely movable under the skin. It was removed under local anæsthesia on May 3, 1933. In the gross it appeared as a white, fibrous, firm, elongated mass 1 centimeter in diameter at its widest point. The cut surface was homogeneously fibrous and white in color. Upon microscopic examination there were interlacing bundles of fibrous connective tissue cells with rather large nuclei. A thin, fibrous capsule surrounded the mass (Fig. 12). Diagnosis: fibroma of tendon sheath. The wound healed well and she was discharged from surgical care on May 16, 1933. There was no sign of recurrence when examined on March 22, 1934.

CASE 9. A. W., No. 63166, a woman, aged 32 years, was admitted to the Rochester Municipal Hospital on September 25, 1932, for removal of tu-

mors from both wrists. She had first noticed a swelling on the dorsum of the left wrist 3 months ago. It was not painful and gave her no trouble until 1 month later. It gradually grew in size and became sensitive. There was also a stiffness of the wrist joint. One month ago a similar swelling appeared on the dorsum of the right wrist. Examination showed a rather large swelling on the dorsum of the left wrist. It was not tender, measured 4 by 4 centimeters in diameter, and seemed soft, almost fluctuant. The swelling over the dorsum of the right wrist was considerably smaller. The tumors were excised under ether anæsthesia. A 12 centimeter linear incision was made in order to expose the tumor of the left wrist. It was found to be about the size of an egg and it enveloped all the extensor tendons running up into the forearm under the annular ligament which had to be divided to expose it. It was soft in consistency but did not seem to contain fluid. It was carefully dissected free from the extensors and the anatomical relations were restored. A similar procedure was necessary on the right, the annular ligament again requiring division. Grossly the specimens consisted of a mass of fibrous tissue. In the specimen from the left there was a thin walled cyst 1 to 2 centimeters in diameter in the center of the growth. The cyst lining was rugose and appeared covered by a serous membrane. Microscopic sections showed masses of dense, fibrous tissue, richly infiltrated in foci with lymphocytes and plasma cells. There were many fibroblastic appearing cells present (Fig. 13). Diagnosis: fibroma with cystic degeneration or ganglion with chronic inflammation. Convalescence was slow because of arthritic changes in the joints which prevented full motion. Progressive arthritis has kept this patient in the out patient clinic for the last 2 years. There has been no local recurrence of the tumors on either side.

Case 10. A. K., No. 46325, a woman, aged 58 years, was admitted to the Strong Memorial Hospital on April 24, 1931. She complained of a tumor of the right knee which had been present for 6 months. It had grown steadily in size and at the time of admission was the size of a hen's egg. Five treatments with roentgen rays had had no effect upon it. Examination revealed an obese woman with otherwise normal physical findings except for the local condition. There was a firm, non-tender mass about 8 centimeters in length underneath the flexor group of muscles on the inner side of the right knee. It was movable, deeply placed and felt like cartilage. Special laboratory examinations were negative. There were no changes in the vital signs. The tumor was removed under local anæsthesia. It was attached to the semitendinosus tendon about 0.5 centimeter above its insertion into the fascia around the knee. The tumor measured 4 by 6 centimeters and was easily freed from the sheath. The tissue was soft, elastic and white with occasional yellowish granular surfaces. Microscopic section showed pale œdematous fibrous tissue which appeared to be degenerated and gelatinoid in areas. There were many large, pale blue staining cells with indistinct cytoplasm. These occurred in vacuolar spaces, and some of them looked like giant cells. The whole tumor gave the impression of a transition stage to preformed cartilage (Fig. 14). Diagnosis: synovioblastoma—transitional to chrondroma. The convalescence was uneventful. She was discharged on May 4, 1931. There has been no recurrence or further trouble to the present.

Case 11. T. F., No. 73777, a man, aged 21 years, was admitted to the Strong Memorial Hospital on April 24, 1933. He had had a tumor the size of a walnut removed from the anterolateral aspect of his right wrist at the age of 4, 17 years ago. The patient remembers having a large rounded tumor in this same region beneath the old scar for at least 10 years. It has not changed in size but there was a time 8 years ago when there was pain and tenderness in the mass. In the last few weeks there has been recurrent discomfort which has become severe enough to prevent the use of the hand during the last fortnight. He thinks that he may have brought on this episode by bowling. There have been no constitutional symptoms. General examination showed a relatively normal individual except for the local condition. Locally there was a long, well healed cicatrix on the lateral side of the volar aspect of the right wrist. There was a fusiform, slightly lobulated, resilient, non-tender mass measuring 3 by 5 centimeters in diameter attached to the deep structures. The skin over it was freely movable. There were no sensory changes in the hand. Extension of the wrist was limited at 10 degrees, flexion at 35 degrees. The opponens power of the thumb was weak. There were no epitroclear or axillary glands palpable. Roentgen ray did not show any evidence of bone involvement (Fig. 15). Under avertin, local and nitrous oxide anæsthesia, the scar of the previous incision was removed and flaps dissected, exposing a long, cylindrical, firm tumor of reddish brown appearance with many dilated vessels running into it. It was not well localized from the surrounding tissue and had to be removed by sharp dissection. It was attached firmly to the annular ligament of the wrist. It was also firmly bound down to the two extensor tendons of the thumb. It was carefully dissected free and removed in one piece. Closure was made in layers with fine catgut and silk. The hand was placed in a cocked up position on a molded plaster splint. Grossly, the tumor consisted of an oval mass of tissue measuring 4 by 2 by 2 centimeters. On section it appeared to be dense fibrous septa separating large vascular spaces. It was surrounded by fat and not definitely encapsulated. Microscopic sections showed numerous densely arranged, various sized blood vessels with fibrous tissue surrounding them. One vessel showed a well organized thrombus in its lumen (Fig. 16). Diagnosis: fibrohæmangioma of the tendon sheaths. He was discharged from the hospital on May 1, 1933. The wound healed well. Physiotherapy was started and wrist joint motion restored to normal after 1½ months. In March, 1934, the wrist was normal and the tumor had not recurred.

Fig. 1. Case 1. The characteristic spindle cells with intercellular fibrils make up the greater part of the picture. Typical giant cells and phagocyted blood pigment are also present but no xanthoma cells were found in the sections studied. × 135.

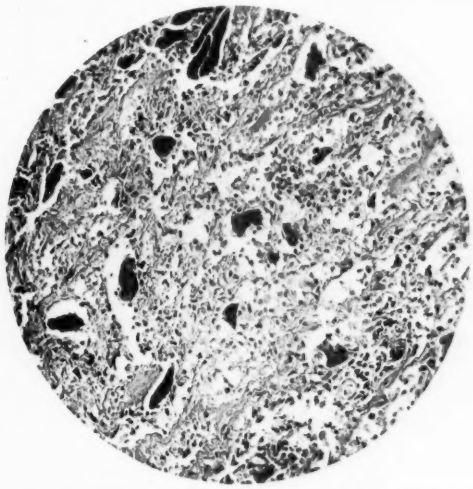


Fig. 2. Case 2. This area shows many giant cells and the more compact type of connective tissue cells with intracellular blue staining material and suggestions of synovial spaces. × 135.

Cases 1 to 6 well illustrate the features of the commonest tumor of the tendon sheaths. These giant cell tumors are characterized by an insidious onset and a relatively slow growth. They are most commonly seen on the tendon sheaths of the hands; and next most frequently on those of the feet. Then, there is a scattering of localization to the tendon sheaths about the wrist and ankle joints. Rarely these tumors occur more proximally to the body. Their seat of origin on the hands and feet makes discovery rather early. Even despite the usual delay of the patient in seeking attention, the size of the tumors is rarely greater than that of a walnut and usually it is even smaller. The tumors about the wrist and ankle tend to be larger. In general, the more peripheral the position the smaller the size and vice versa. There have been cases reported the size of a fist (Ali Krogius' Case 1); the size of a goose egg (Kurtz); "of unusual size" where the tumor occupied the whole central part of the foot (Ragius); and as large as a hen's egg (Sprenger), (Gonzalez-Aguilar). Occasionally the growth becomes accelerated after a slow development over a period of years. Symptoms which may arise are due to limitation of function of involved tendons or pressure on nerves. When a large nerve is involved, paroxysms of pain may occur as in Kurtz's case. Pressure on bones may be so gradual as to cause no symptoms but may result in erosion, or replacement of bone (as in Harbitz's Case 4 or Ragius's Case 1); or pressure atrophy with deformity (Esau and Hueckel) and (author's Case 5); occasionally infection of the tumor occurs (author's Case 2). The tumors are usually smooth, rounded, or lobulated. They give an impression of being hard or elastic. Sometimes they are slightly tender on firm pressure. The skin is freely movable over them and they change position with motion of the involved tendon. Sometimes they occupy a position lateral to the sheath. Occasionally more than one tumor is present (Jebens' case) (author's Case 3). The tumors are well encapsulated and shell out readily at operation. The tendon and surrounding structures are not involved as a rule. Attachment to the periosteum may occur when such a tumor arises from a bursa (Hertzler). Very rarely invasion of the tendons themselves is noted (Ollerenshaw's case; author's Case 6); but these two examples are

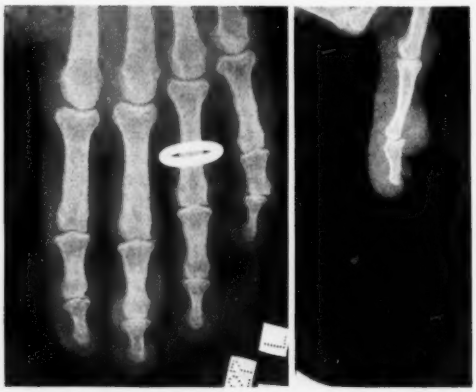


Fig. 3. Case 3. The roentgenogram shows a soft part dense swelling with no involvement of the bone.

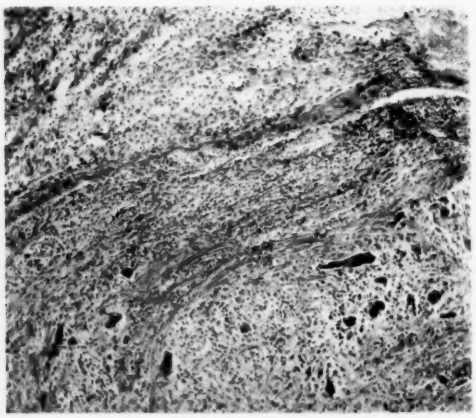
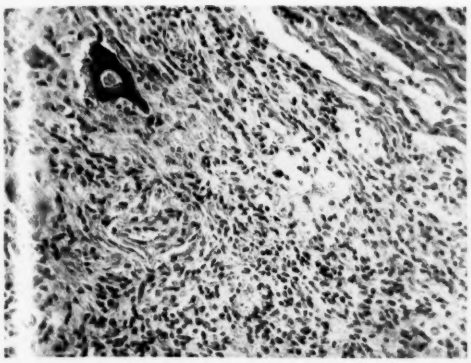


Fig. 4. Case 3. In the upper left hand corner there are xanthoma cells with foamy cytoplasm and central small dark staining nuclei. The rest of the section shows dense fibrous tissue with giant cells; and occasional areas of blue staining intercellular substance.

the only cases of this kind in the literature. There is rarely a recurrence if operation has been properly executed but when it is incomplete recurrence may take place (author's Case 3). Metastasis from this type of tumor is not reported. In gross appearance the tumors are varied in color. White, grey, red, brown, and yellow are frequently described as the predominant hues. When the characteristic bright yellow or red brown splotches are noted interspersed through the tumor, the surgeon can be reasonably sure that he is dealing with a growth of this type.

The microscopic appearance of these growths is also perfectly characteristic. The basic cells of these tumors are either typical fibroblasts with abundant or sparse intercellular fibrils; or more compact blunted connective tissue cells with ovoid nuclei and homogeneous blue staining intercellar material. These probably represent the synovial connective tissue cells and, as a further evidence of it, synovial spaces may be encountered in these areas (King). In addition to these cells, there may be found giant cells; xanthoma cells; blood pigment; and cholesterin crystals. The giant cells and xanthoma cells may be taken to represent the endothelial structures in the tumors, reacting in response to the presence of the foreign bodies—blood pigment and cholesterin crystals. Giant cells and xanthoma cells are actively phagocytic and may disappear when the foreign material has been cared for. Consequently, the presence of these scavengers is more or less fortuitous but of definite diagnostic value as an indicator of the nature of the growth.

There has been considerable discussion and difference of opinion in regard to the true classification of these growths (3, 10, 13, 15). They have been classified as inflammatory by many observers, the reaction to trauma being assigned as one etiological factor. Many look upon them as granulomata. Still another group considers them as due to imbalances in the metabolism of the lipoids especially cholesterol. And lastly they are thought to be true benign neoplasms by a large number of competent pathologists. In many respects they bear a close analogy to the giant cell tumor of bone. It has long been known that there are infiltrations of the skin and other organs with lipoid containing xanthoma cells in systemic diseases such as diabetes, nephrosis, etc. Also, any systemic condition which disturbs the lipoid metabolism such as jaundice may be associated with hypercholesterolæmia and a deposit of lipoids in certain locations. Nevertheless, it does not follow, that there is always a systemic derangement in these cases simply because giant cell tumors of tendon sheaths have been found in the presence of such a systemic disorder as in the



g. 5. Case 4. There are xanthoma cells in the central p of the section. Phagocytic giant cells are prominent on th eft. The variation in size and shape of the connective ti e cells is characteristic. × 150.

cases of McWhorter and Weeks, Kusnetzowsky, and Ollerenshaw. In fact quite the contrary has been the result in many carefully studied clinical cases. For instance in our Case 6 the blood chemistry and cholesterol determinations were repeatedly within normal limits. This case might reasonably have been expected to be on a systemic basis because of the bilateral distribution of the tumors and the close resemblance to that of Ollerenshaw. A very similar analogy obtains for giant cell tumors of bone in the presence of hyperparathyroidism. Collections of giant cells in this condition may be found in relation to the cystic areas in the bones but these do not constitute giant cell tumors any more than the patches of xanthelasma in the skin constitute giant cell xanthomatous tumors. Ely has reported the simultaneous occurrence of a giant cell tumor in the fibula and in the peroneal tendon sheath, but there are no other cases of this kind recorded. The weight of evidence at present seems to indicate that the localized growths of the tendon sheaths are not the manifestations of a general disease but true benign neoplasms. It is an open question whether these growths could be made to take on malignant characters by repeated insults as is certainly the case in giant cell tumors of bone. It is unfortunate that so many terms have been used to describe the benign giant cell tumors of the tendon sheaths. Until further evidence is forthcoming it seems that it

Fig. 6. Case 5. The roentgenogram shows the dense soft part shadow and the pressure atrophy of the outer aspect of the cuboid. It is sometimes difficult to differentiate between a secondary involvement of bone and a primary bone tumor with extension to the soft parts.

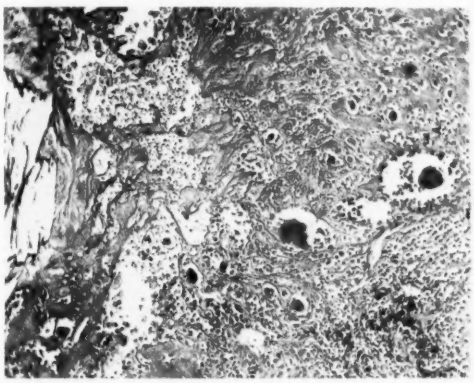


Fig. 7. Case 5. To the left of the section there is a mass of cholesterin crystals; next to which are collections of typical xanthoma cells. In the lower right hand corner is a mass of blood pigment. Giant cells are present scattered throughout. Compact blunted connective tissue cells with much bluish staining intercellular material comprises the bulk of the section. × 75.

Fig. 8. Not only were the sheaths involved on both sides but the tendons were greatly enlarged and infiltrated with tumor nodules.

would be well to regard the designations giant cell sarcomata, giant cell myelomata, or sarcomata with myeloplaxes as incorrect.

Cases 7 to 11 illustrate some of the variations which may be encountered in these tumors of the tendon sheaths. Case 7, for example, might be considered a pure fibroma of adult type cells. The section suggests in places that the cells are undergoing degeneration. It is quite likely that this is evidence of secretory activity with no normal outlet. There are many slit-like openings which may represent synovial spaces. In Case 8, on the

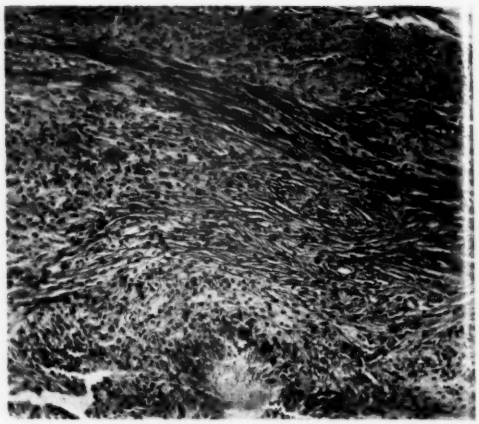


Fig. 9. Case 6. A small area with giant cells is seen in the lower central portion of the section. Just above it are cells containing lipochrome granules. On special fat stains these cells are quite numerous and are interspersed throughout the field. The main mass of the tissue consists of relatively young fibroblasts replacing and invading the normal tendon structure which is shown traversing the upper part of the field. × 75.

other hand, the fibroma consists of interlacing bundles of a more immature type of connective tissue. This may well be the late stages of a synovioma which is going over into pure fibrous tissue. Case 9 is a beautiful example of one of these synovial sheath tumors which are loosely grouped under the term "ganglion." There are clearly reproduced synovial fringes and papillary projections into spaces occurring in this tendon sheath tumor. The infiltration with cells of a chronic inflammatory type further emphasizes the similarity to the synovial villi seen in chronic arthritis. These tumors were clinically not the typical ganglia but much more truly neoplastic in nature. It is certain that they would be considered neoplastic by most pathologists as the main mass of the tumor consisted in dense fibroblastic tissue. The fact that these synovial cells have gone on to complete differentiation with reproduction of the characteristics of synovial membranes is a true indication of their origin. It is customary to look upon ganglia as fibrous tumors which have undergone cystic degeneration. It would seem much more logical to look upon them as tumors originating from synovial cells which have pre

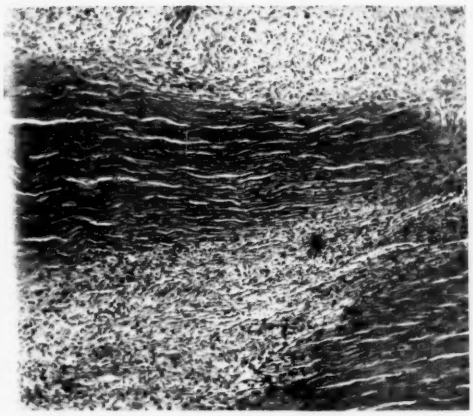


Fig. 10. Case 6. This section shows the normal tendon dark staining—being crowded aside and invaded by an tively growing connective tissue. × 75.

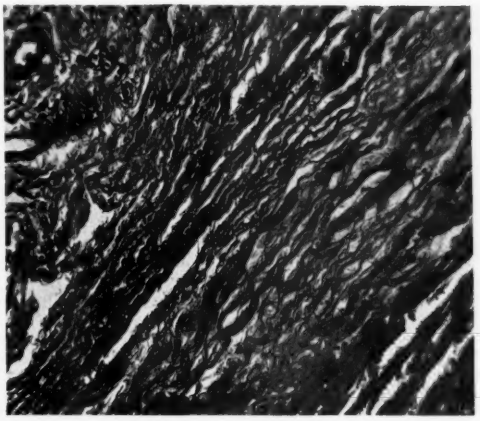


Fig. 11. Case 7. The section is mainly composed of connective tissue cells of adult type. There are numerous slit-like synovial spaces. × 75.

rved their function of secreting mucin for hich there is no outlet, and hence a cyst rms. Certainly pathologically, there is little idence to support the theory that the cysts ise from degeneration in these tumors. Case 10 shows that the synovial cells possess markable powers of differentiation. The lls are blunted, the nuclei rounded. There is an abundance of blue staining mucinous material as an intercellular ground substance. The whole tumor shows this structure quite uniformly and areas such as that in the center of the illustration represent a transition to cartilage. In time this tumor would have undoubtedly become a true chondroma of the tendon sheath. A number of examples of chondroma of the tendon sheaths have already been reported (Janik, Brenckmann and Jung, Chevrier). Case 11 affords a perfect example of a rather uncommon tumor of the tendon sheaths which had recurred after incomplete removal years previously. Burman and Mil-

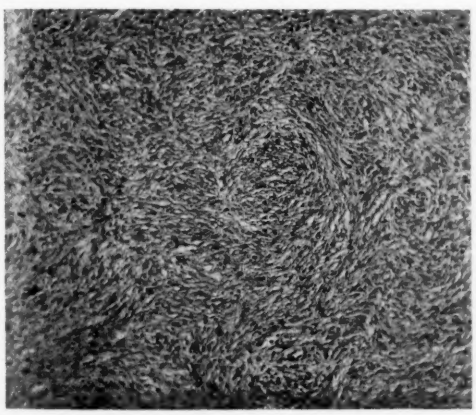


Fig. 12. Case 8. There are many interlacing bundles of connective tissue cells with numerous fibrils in this section. It may be considered a fibroma of the tendon sheath. × 75.

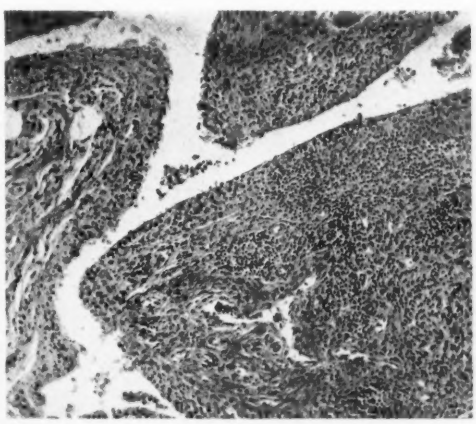


Fig. 13. Case 9. Projecting papillary growths of synovial origin with chronic inflammatory infiltration found in the central portion of a dense fibrous tissue tumor. This well illustrates the origin from synovial connective tissue. × 75.

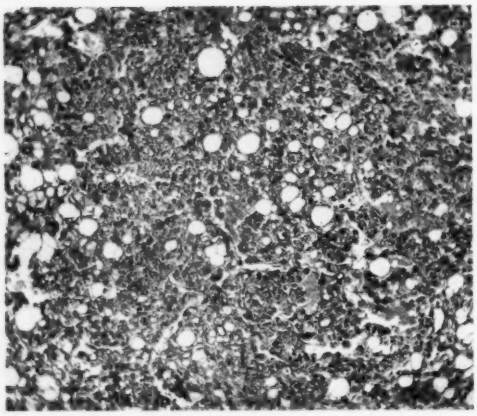


Fig. 14. Case 10. The central portion of the section shows early cartilage forming from synovial cells. × 75.

gram have assembled 16 cases of these hæmangiomata. N. Della Mano and Principalli in 1933 added typical examples to the literature.

Fig. 15. Case 11. Large soft part density without bone involvement. It is subcutaneous and surrounds the tendons.

There were no instances in our cases of the more unusual forms of tumors such as lipomata (Strauss, White, Brandão, Chiarissimo, Valdoni); lymphangio-endotheliomata (Faldini, Scagliosi, Huguenin and Oberling, Principalli); nor of the malignant varieties of which there are reported cases scattered through the publications on collected tendon sheath tumors (Tourneaux, Harbitz, Janik, etc.).

At this point it seems logical to consider the embryology and biology of the synovial cells. Recent studies have furnished increasing evidence of their undoubted mesenchymal origin. It has been established that all cells having such an origin possess the capacity of reverting to the primitive fibroblast (12). From tissue culture studies on synovial cells, Vaubel has been able to demonstrate that these cells produce mucin not as a cellular degeneration, but as a true secretion. He regards this mucin production as a ground substance of the synovial tissue analogous to the intercellular substance of the cartilage matrix except that it persists in a liquid state. Under certain conditions the synovial cells exhibit a decided polymorphism—varying in contour from round to polygonal to almost epithelial appearances on the one hand and to typical spindle forms on the other. There is also morphological evidence that the synovial membrane is a spe-

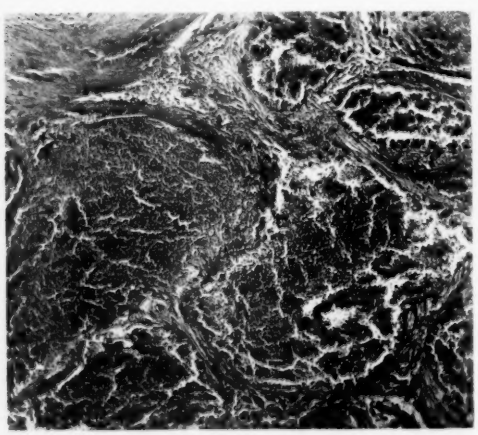


Fig. 16. Case 11. The microscopic picture is of spaces filled with red blood cells surrounded by a wall of fibrous tissue. The whole section is typical for fibrohæmangioma. × 75.

cialized type of connective tissue (Segale). On studying the histology of normal and abnormal synovial membranes, the importance of the varying underlying supporting tissue was brought out by Key. These supporting tissues offer a considerable range of morphology from areolar to adipose to fibrous in nature. King has drawn attention to the transitions of the synovial cell through a pseudo-cartilage to a true cartilage cell in the regions where the synovia attach to the cartilage. The richness of the blood and lymphatic supply to the synovial membrane offers a chance for endothelial elements and their derivatives to take part in the tumor formation. In summary, the synovial cell is one which enjoys multipotential variations. Under some conditions it may revert to the primitive type spindle form connective tissue; but it is closely related to the cartilage and bone cells and in certain areas possesses the ability to differentiate in the direction of cartilage. This primitive synovial cell may be designated as a synovioblast to correspond to similar chondroblasts and osteoblasts of the precursors of cartilage and bone.

The tumors which arise from the tendon sheaths, then, may consist of the synovial cell and its variants as the central figures. But the supporting areolar, fibrous or fatty tissue may also take a part in the formation of the growth; and the endothelial elements may enter from the richness of the blood and lymphatic supply. From the endothelium, scavenger cells such as macrophages, giant cells and reticulo-endothelial cells, may escape to lend variety and color to the tumor. The pathologist has as his task the sifting of the essential from the non-essential elements. He must, if possible, assign the proper weight to each component of the growth. If proper recognition can be given to the site of origin, it may be useful to draw up a tentative classification which has the merit of applying equally well to the growths of tendon sheaths, bursæ, and joints. Such a schema is herewith subjoined in the hope that it may serve as a working basis for a more complete classification of these tumors as material accumulates.

Synoviogenic tumors. Tumors having their origin in the synovial membranes of tendons, bursæ, joint capsules, and joint linings.

Benign

Tendon sheaths	Joints and Bursæ
a. synovioblastoma	"ganglion". synovioblastoma
b. fibroma	fibroma
	intra-articular
	extra-articular
c. chondroma or osteochondroma	chondromatosis
d. giant cell xanthoma	giant cell synovial membrane tumor
e. angioma	angioma
hæmo	hæmo
lymph	lymph
f. lipoma	lipoma

Malignant—Synoviogenic sarcomata—These contain many of the elements derived from the synovial membranes or from the tissues in apposition to them. The cases reported are as yet too few in number to separate out anatomic types.

Metastatic involvement of tendons, bursæ or joints practically never occurs.

CONCLUSIONS

Tumors of the tendon sheaths are closely related to tumors of joints and bursæ.

The basic cell of all these tumors is the synovial cell.

The synovial cell is a modified mesenchymal cell with multipotential qualities.

It may revert in one direction to the fibroblast or may go over into cartilage and bone in the other.

Evidence is presented to support this contention and a tentative classification of tumors of the tendons, joints, and bursæ is proposed.

BIBLIOGRAPHY

1. Brandão, F. Lipoma arborescens of tendon sheaths. Chir. d. organi di movimento, 1925, ix, 235–244.
2. Brenckmann, E., and Jung, A. Chondromes des gaines des fléchisseurs de la main. Rev. d'orthop., 1929, xvi, 176–180.
3. Broders, A. C. Benign xanthic extraperiosteal tumor of the extremities containing foreign body giant cells. Ann. Surg., 1919, lxx, 574–581.
4. Burman, M. S., and Milgram, J. E. Hæmangioma of tendon and tendon sheaths. Surg., Gynec. & Obst., 1930, l, 397–406.
5. Chevrier, L. Fibro-chondromatose du prolongement synovial bicipital. Bull. et mém. Soc. nat. de chir., 1932, lviii, 565–566.
6. Chiarissimo, G. Avroldi. Lipoma della guaina del tendine del peroneo anteriore. Riforma med., 1929, xlv, 979–980.
7. Della Mano, N. Angioma cavernoso delle guaine tendinee. Policlin. (sez. chir.), 1932, xxxix, 593–612.
8. Ely, L. W. Giant cell growth of bone and tendon sheath. Ann. Surg., 1918, lxviii, 426–430.
9. Esau and Hueckel, R. Eine scheingeschwulst einer Handbeugeschne. Deutsche Ztschr. f. Chir., 1928, ccix, 270–275.

10. Ewing, J. Neoplastic Diseases. 3d. ed., pp. 276–315. Philadelphia: W. B. Saunders Co., 1931.
11. Faldini, G. Linfo angio-endotelioma delle guaine tendinee. Chir. d. organi di movimento, 1928, xii, 417–432.
12. Fischer, A., and Parker, R. C. Proliferation und Differenzierung. Arch. exper. Zellforsch., 1929, viii, 297–324.
13. Fleissig, J. Ueber die bisher als Riesenzellensarkome (Myelome bezeichneten Granulations geschwuelste der Sehnenscheiden). Deutsche Ztschr. f. Chir., 1913, cxxii, 239–265.
14. Gonzalez-Aguilar, J. Contribution to the pathogeny of tendon tumors of giant cells. J. Bone & Joint Surg., 1930, xii, 280–288.
15. Goeroeg, D. Ueber die Riesenzellen geschwueltze der Sehnenscheiden. Centralbl. f. allg. Path. u. path. Anat., 1932, liii, 341–347.
16. Harbitz, F. Tumors of tendon sheaths, joint capsules and multiple xanthoma. Arch. Path. & Lab. Med., 1927, iv, 507–527.
17. Hertzler, A. E. Surgical Pathology of the Skin, Fascia, Muscles, Tendons, Blood and Lymph Vessels. p. 194. Philadelphia: J. B. Lippincott Co.
18. Huguenin, R., and Oberling, C. Lymphangiomes des tendons. Bull. de l'Ass. franç. p. l'étude du cancer, 1931, xx, 144–150.
19. Janik, A. Tumors of tendon sheaths. Ann. Surg., 1927, lxxxv, 897–911.
20. Jebens, E. H. Myeloma of tendon sheath. Proc. Roy. Soc. Med., 1932, xxv, 1098–1099.
21. Key, J. A. The reformation of synovial membrane in the knees of rabbits after synovectomy. J. Bone & Joint Surg., 1925, xxiii, 793–813.
22. King, E. S. J. Concerning the pathology of tumors of tendon sheaths. Brit. J. Surg., 1931, xviii, 594–617.
23. Krogius, Ali. Zur Kenntnis der s. g. Xanthosarkome der Sehnenscheiden. Acta chirurg. Scand., 1922, lv, 263–383.
24. Kurtz, A. D. Xanthoma of tendon sheaths. Am. J. Surg., 1929, vii, 862–864.
25. Kusnetzowsky, N. J. Ein Fall multipler xanthomatoeser granulome der Sehnen. Arch. f. klin Chir., 1923, cxxiv, 73–80.
26. Mason, Michael L., and Woolston, W. H. Isolated giant cell xanthomatic tumors of the fingers and hands. Arch. Surg., 1927, xv, 499–529.
27. McWhorter, J. E., and Weeks, C. Multiple xanthoma of the tendons. Surg., Gynec. & Obst., 1925 xl, 199–206.
28. Ollerenshaw, R. Giant-celled tumors of tendon associated with xanthelasma. Brit. J. Surg., 1923, x 466–468.
29. Principalli, S. Contributo alla conoscenza de tumori vascolari delle guaine tendinee. Chir. d organi di movimento, 1932, xvii, 128–132.
30. Ragius, A. B. Benign tumors of tendon sheaths of unusual size. Ann. Surg., 1931, xciii, 683–690.
31. Scagliosi, G. Contributo allo studio dei tumori benigni delle guaine tendinee (Linfangioma delle guaine tendinee di ambo i muscoli tibiali posteriori). Chir. d. organi di movimento, 1931, xv, 530–542.
32. Segale, C. Ueber die Regeneration der Synovial membran und der Gelenk kapsel. Beitr. z. klin. Chir., 1913, lxxxvii, 259–298.
33. Sprenger, W. Zur Kenntnis der xanthomatosen Riesenzellgranulome der Sehnenscheiden. Arch. f. klin. Chir., 1932, clxix, 683–687.
34. Strauss, A. Lipoma of tendon sheath with report of a case and review of the literature. Surg., Gynec. & Obst., 1922, xxxv, 161–171.
35. Tourneaux, J. P. Les Sarcomes des gaines tendineuses. Rev. de chir., 1913, xlvii, 817–854.
36. Valdoni, P. Lipoma arborescente sistemico delle guaine tendinee della mano e del piede. Chir. d. organi di movimento, 1931, xv, 509–529.
37. Vaubel, E. The form and function of synovial cells in tissue culture. I. The morphology of the cells under varying conditions. J. Exper. Med., 1933, lviii, 63–83; II. The Production of Mucin. J. Exper. med. 1933, lviii, 85–95.
38. White, J. R. Arborescent lipomata of tendon sheaths—a report of two cases. Surg., Gynec. & Obst., 1924, xxxviii, 489–490.

INDICATIONS FOR THE SURGICAL TREATMENT OF CARCINOMA OF THE STOMACH

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THE cure of cancer of the stomach by surgical treatment has been accomplished in a sufficient number of cases to remove any doubt that cure is possible under certain circumstances. It is unfortunately true, however, that the number of cures in relation to the incidence of the disease is pitiably small. If, however, the possibility is considered of the curability of carcinoma of the stomach when it is still confined to the walls of the stomach and is widely removed, it is found that about 50 per cent of the patients are alive and apparently without recurrence 5 years after operation. The earliest possible recognition of the growth and its prompt and thorough removal, therefore, is the hope of the patient with carcinoma of the stomach. In addition to the possibility of cure, surgical treatment properly applied in many of the less favorable cases will prolong life, will protect against disagreeable complications, and in many respects will fully justify such treatment.

In regard to the most important factor in increasing the percentage of cures, that is, early diagnosis, it is an unfortunate paradox that although the disease readily can be identified in its early stages, this is rarely done. The competent fluoroscopist may, in rare instances, fail to detect early carcinoma of the stomach, but all too often the first fluoroscopic examination discloses advanced disease. The chief reason for this frequently has been pointed out, namely, the early clinical signs of carcinoma of the stomach are often so vague and apparently so insignificant, that the necessity of the only examination (roentgenological) by which the early, symptomless lesion can be detected is easily overlooked. To avoid this error, which interferes so seriously with increasing the efficiency of treatment of the disease, is a problem of modern medicine which presents unusual difficulties.

When a pre-operative diagnosis of carcinoma of the stomach has been made, or a lesion which may be malignant has been demonstrated roentgenologically, the basic indication for treatment is that unless definite metastasis can be demonstrated, surgical exploration of the growth is warranted. This principle cannot always be followed, for there may be clear evidence, such as involvement of the cardia, that the growth is irremovable. The conscientious surgeon, however, should view the situation from the standpoint that cure may sometimes be brought about in cases in which, on pre-operative examination, the disease appears too far advanced for cure. Such a view tends, of course, to decrease the rate of resectability when based on the number of cases in which exploration is made, to increase the rate of resectability when based on the number of patients whose condition is diagnosed as carcinoma of the stomach, and also to increase the operative mortality rate. The effectiveness of surgical treatment is greater with such practice, however, both in respect to the number of cures and to the degree of palliation.

The question of whether metastasis is present in carcinoma of the stomach is of first importance in determining whether or not surgical treatment is indicated. Fortunately early distant metastic growths occur in situations in which they can be detected by careful examination and when they are found the situation is clarified in so far as any prospects of cure are concerned, but when they are overlooked unnecessary exploration may be made. The most common sites of distant signs of incurability are the supraclavicular lymph nodes and the peritoneum of the rectal shelf. Nodules in either site denote incurability, but not always undesirability of exploration. When enlarged lymph nodes are palpable in the supraclavicular area, and the patient is known to have carcinoma of the stomach, the nodes must be considered metastatic until proved otherwise. Usually they

fit into a picture already identified as that of inoperability, and the assumption that they are malignant is warranted. Occasionally, however, the primary growth is small, obstruction is present or is impending, and the enlarged lymph nodes are not as typical of metastatic nodules as those which usually are encountered. It is then necessary to excise, under local anæsthesia, a nodule satisfactory for microscopic examination, and treatment is then directed according to the result of this study. If the excised node is malignant, operation is always contra-indicated even if marked obstruction is present, for the life of the patient is so near an end, that non-surgical treatment of the obstruction is best. If the nodes prove to be inflammatory and there are no other detectable metastatic growths, exploration is indicated unless the lesion or its local extension or other factors make exploration unwise.

Involvement of the peritoneum of Douglas' pouch should be most carefully sought for, as this may be the site of not only an early, but also of the only metastasis. Rectal examination of patients with carcinoma of the stomach should never be omitted, should be made after the bowel is cleared of fæcal material, and the patient should be examined in both the lithotomy and knee-chest positions. Peritoneal implantation in Douglas' pouch is usually sufficiently well defined either because of the almost cartilaginous feeling of the tissue, as described by Blumer, or because a distinct nodular mass is fixed to the pelvic peritoneum as it is reflected from the anterior aspect of the rectum. Not infrequently, however, a sense of rigidity of this portion of the peritoneum may arouse only suspicion that implantation has occurred, and in the absence of definite nodules, exploration of the gastric lesion may be advised if it is otherwise indicated. The mechanism of pelvic implantation from a gastric lesion probably differs from that of supraclavicular metastasis. The latter obviously takes place through the lymph channels, and the former apparently is by direct implantation of cells. The most striking example of such implantation is seen in the Krukenberg tumors; examples of such tumors have been encountered in the form of large malignant, pelvic tumors secondary to small, non-perforating carcinomata of the stomach which caused no digestive disturbance, and which were not detected until the pelvic tumors had been removed. It is because these rectal secondary growths are probably true implants that operation on the primary growth may occasionally be advisable even when secondary rectal growths are definitely present. For example, the patient who is in good general condition but who has an antral lesion that is producing obstruction may be greatly benefited by operation both in respect to relief of symptoms and length of life, even if growths in the rectal shelf are encountered in the course of the pre-operative examination.

The more common adjacent sites of metastasis are the liver and the region of the umbilicus, and when such metastatic growths are demonstrable clinically, operation is contra-indicated regardless of other circumstances. A nodule in the region of the umbilicus may be so small that its excision is advisable to permit more positive examination, and the difficulties of determining by clinical examination whether or not an enlarged liver is secondarily involved, are well known. The applicability in these cases of more recent methods of roentgenological visualization of metastatic nodules in abdominal organs by administration of thorotrast is as yet unknown. If doubt exists as to whether metastasis to the liver has taken place, and if circumstances otherwise indicate that exploration is warranted, it should be done. The indications for surgery when intra-abdominal metastasis is encountered after the abdomen is opened will be discussed later.

Extra-abdominal metastasis is relatively rare with carcinoma of the stomach, except in the supraclavicular lymph nodes. For example, pulmonary metastasis is so rare that it is not the routine in The Mayo Clinic to make a roentgenogram of the thorax in these cases. In a study of all the roentgenological examinations of the lung made in the clinic up to 1930, Kirklin and Ochsner found that pulmonary lesions definitely secondary to carcinoma of the stomach were extremely uncommon, and only 3 instances could be found. There was 1 case each of involvement of the right lung, the left lung, and both lungs. In 2 of

these cases the lesions were circumscribed; in the other, the lesion was of the infiltrative type. The suspicion, therefore, that the disease is more advanced than the local lesion makes it appear to be, should be confirmed by roentgenograms of the thorax.

Abdominal metastasis other than the forms mentioned are not infrequently detectable or suspected by the demonstration of fluid or of extragastric masses, and such findings definitely contra-indicate any surgical treatment.

The significance of irremovable metastasis discovered at exploration, therefore, is incurability, but, as will be pointed out, such growths may in certain circumstances not preclude the possibility of long continued palliation by removal of the primary growth.

Examination of the upper part of the abdomen frequently will disclose findings of importance in deciding as to the advisability of operation, and when such information is correlated with the roentgenological report of the character of the lesion, as shown by fluoroscope and roentgenogram, the possibilities of surgical treatment become more predictable. There are, however, frequent apparent inconsistencies between physical findings and surgical possibilities. The most common fallacy is that the non-palpable growth is more likely to be found removable than the palpable one, but the reverse is often true. The large growth often is of the colloid type, with sharply defined margins, whereas the small lesion may extend by infiltration and have little tendency to formation of tumor. When the growth can be palpated, its mobility is of extreme importance in estimating the possibility of removal. A very large tumor, freely movable, particularly laterally, is perhaps more likely to be found resectable than a small tumor which is more or less fixed. A high lying lesion, the edge of which presents at the left costal margin on inspiration, on shifting the position of the patient may be found to be mobile and accessible. I have observed cases in which the condition apparently was inoperable, because a tumor was situated in the fundus and was concealed by the thoracic wall; however, the growths were readily removed because they involved chiefly the greater curvature. The large, fixed tumor is almost always inoperable, and when it extends to the right enough to make difficult its differentiation from an enlarged and involved liver, exploration should be advised against. Multiple tumors are also almost certain evidence of incurability, for they usually represent malignant infiltration of the great omentum.

The correlation of physical findings with the roentgenological report is exceedingly important and is later discussed.

The age of the patient is important in considering the advisability of operation for gastric carcinoma. Other things being equal, the younger the patient the more clear are the indications for exploration, and it is on relatively younger patients that the most extensive operations are justified. Total gastrectomy, for example, does not seem a reasonable procedure if a patient is 70 years of age, whereas the same procedure might be justifiable if a patient were 50. The possibilities of cure of younger patients, moreover, are as good as when patients are older, a fact which is contrary to what I believe is the general impression. Gray, for example, in a study of 273 patients who obtained 5 year cures following resection done in the clinic, showed that the percentage of cures was as high among patients who were in the decade of life from 35 to 45 years as among those who were in the decade from 60 to 70 years. The practice, therefore, of attempting to carry out gastrectomy for the more extensive lesions of young patients is sound.

The condition of the patient is not always easy to judge correctly, in so far as the operative risk is concerned. Extremes are significant. The patient who is markedly overweight constitutes a poor risk, as does the patient who has lost much weight, particularly if loss has been rapid. Of these, however, the patient who is underweight apparently has less liability to complications, such as those referable to the lung, than have patients who are overweight. In the average case, estimation of the condition of the patient who has no other organic disease is largely speculative, since the factors which have to do with recovery are too intangible to be measured. The mortality rate of gastric resection among women, for example, is consistently lower than

among men, as is true in many other surgical procedures. Extreme anæmia in the absence of previous gross hæmorrhage is an unfavorable sign, but moderate secondary anæmia apparently is not. In fact, I am under the impression that moderately anæmic patients withstand operation for gastric carcinoma even better than those with a normal blood picture. Recent development of œdema of feet and ankles suggests an inoperable lesion as well as increased risk.

Pain in gastric carcinoma has significance in respect to operability. Although distress is a common symptom, severe pain is rare, and usually is the result of extragastric involvement from penetration or perforation of the growth. Because of this, pain is an unfavorable sign, and when it is pronounced, and particularly when it is referred posteriorly, the possibilities of thorough removal of the growth are remote, even if the size and situation of the lesion apparently favor removal.

Of significance also is a marked sensation of fullness after ingestion of a small quantity of food. Although fullness after eating is one of the most common of the early manifestations of gastric carcinoma, and therefore of no particular significance from the standpoint of operability, inability to take small quantities of food or drink usually is evidence that extensive involvement of the walls of the stomach already has taken place. Dysphagia suggests encroachment on to the cardia and is a bad prognostic sign.

The value of laboratory investigations in carcinoma of the stomach, from both diagnostic and prognostic standpoints, is very limited. It is now well known that little dependence can be placed on the presence or absence of free hydrochloric acid in diagnosis of the disease, since in approximately 50 per cent of cases of proved carcinoma of the stomach, free hydrochloric acid is present. From a prognostic standpoint it has been interesting to find that studies made by Gray of patients cured by gastric resection, demonstrated that the rate of curability was definitely higher among those with achlorhydria than among those with hydrochloric acid, and apparently the higher the value for acid, the less the prospect of cure.

The correlation between clinical signs and symptoms on the one hand, and roentgenological examination on the other, is of the greatest importance. Fluoroscopic and roentgenographic examination by a competent roentgenologist will give more definite information as to the characteristics of the growth than all other methods combined. Roentgenology is not correctly employed, however, if the findings are not properly correlated with the clinical signs and symptoms. A report, for example, of an inoperable carcinoma of the stomach may surprise the clinician who has found the patient in fairly good condition, with a freely movable, although large, tumor. Further consideration, with possible re-examination by the roentgenologist, may qualify the report to the extent that it is agreed that surgical exploration of the growth should be advised. On the other hand, a negative roentgenological report may confuse the experienced clinician who, without definite clinical symptoms or findings, suspects that malignancy of the stomach is present. Re-examination by the roentgenologist is then imperative, since certain small lesions of the fundus occasionally are detectable only by repeated fluoroscopic and roentgenographic examination. If the roentgenological findings are still negative, but the clinician's suspicions are not allayed, and if clinical evidence does not justify exploration, the patient should be advised to have further roentgenological studies made in 6 weeks or 2 months, regardless of the course of the symptoms. Roentgen rays, in their effect of providing information that in no other way is obtainable, may disclose some anatomical abnormality which to the surgeon introduces unusual possibilities. For example, Kirklin on one occasion drew my attention to a case in which the entire stomach apparently was involved in malignant disease, but the abdominal portion of the œsophagus was so prolapsed, and entered the lesser curvature at such a point that I found total gastrectomy with œsophagojejunostomy to be a relatively simple procedure. Since exploration already had been carried out elsewhere on the patient and the condition had been pronounced inoperable, advisability of another exploration was determined entirely from the roentgen-

ological report. This patient weighed 75 pounds (34 kilograms) at the time of operation; she gained 35 pounds (15.9 kilograms) after operation and lived more than 2 years in comfort and enjoyment of an active life before succumbing to hepatic metastasis.

The limitation of roentgenology in the field of gastric malignancy is in identifying the small ulcerating lesion, and the experienced roentgenologist will be cautious in giving a positive opinion as to the question of malignancy in the presence of these small lesions. Kirklin and Eusterman recently have presented some important criteria on which at least a provisional diagnosis can be given. In so far as the indications for surgical treatment of the questionable gastric lesion is concerned, I believe it is generally accepted that unless an ulceration continues to exhibit a benign character by consistent and definite healing, it should be assumed to be at least potentially malignant and should be dealt with accordingly.

The indications for operation in cases of gastric carcinoma require selection of the optimal time for operation. The risk of resection under the most favorable conditions is not great considering the seriousness of the problem, but the attainment of a low mortality rate, provided it is consistent with the highest possible rate of operability and thorough removal, is an accomplishment demanding most meticulous care in all the details involved in treatment. The patient should then be in the best condition possible for operation, and this frequently requires hospitalization so that the effects of obstruction may be overcome, dehydration counterbalanced, the stomach cleansed, and nutrition improved as much as is reasonably possible.

Exploration for carcinoma of the stomach should be carried out under anæsthesia adequate to permit accurate determination of what can be accomplished. For this reason, local anæsthesia must be used with a consciousness of its limitations. Abdominal wall block is frequently employed in the clinic to permit exploration for carcinoma of the stomach, but in those cases in which it is not immediately apparent that either the growth is removable or that peritoneal implants give evidence of inoperability, a general anæsthetic is given to permit thorough examination to determine the extent of the disease. The incision should vary with the situation of the growth. An incision in the median line is satisfactory for lesions of the body and antrum; for fundic lesions, or for those in which total gastrectomy is contemplated, a left rectus incision is advantageous.

Unless it is clearly apparent that the disease is incurable because of peritoneal implants, careful abdominal exploration should first be made. This exploration should include the routine examination which would disclose any independent lesions or disease which might be detectable. Examination of the gall bladder and of the biliary tract, therefore, is of particular importance because of the frequency of disease in these structures. The importance of a record of any other lesion within the abdomen cannot be overestimated. As an illustration of this fact, I can recount the case of a man aged 70 years, on whom I operated for an extensive carcinoma of the stomach, and for which subtotal gastrectomy was performed, supposedly as a palliative procedure only, since the apparently involved lymph nodes could not be removed. The gall bladder was almost entirely filled with small stones. Any operation on the gall bladder, however, was contra-indicated at this time. The patient made a satisfactory convalescence from operation, and 4 years later, after a period of pain and distress, jaundice appeared. If it had not been known that gall stones were present, the jaundice might have been looked on as evidence of recurrence of malignancy in the liver or biliary tract. The excellent condition of the patient, however, warranted further operation, and at this time, 4 large stones were removed from the common bile duct. It is of interest that there were no calculi in the gall bladder, and there was also no evidence of any recurrence of carcinoma in the upper part of the abdomen; the unremoved, enlarged lymph nodes which it had not been possible to remove at the time of the gastrectomy had entirely disappeared. Recently the patient has reported himself to be in excellent health, 2 years after the last operation.

The chief importance of exploration, however, is to determine whether distant and irremovable abdominal metastatic growths are present. The rectal shelf should always be explored, since peritoneal implants may be present which were not detectable during the clinical examination. If definite implants are found, but no other evidences of peritoneal involvement can be discerned, surgical treatment of the lesion must be considered from the viewpoint that the disease is obviously incurable. In spite of this, the growth occasionally is so situated that resection is not only possible but advisable, because of the relative ease with which resection can be done and because of the protection it will afford the patient against the early onset of obstruction. The presence of peritoneal implants clearly contra-indicates any attempted palliation by surgical means.

Recognizable metastasis in the liver is usually a definite contra-indication to any surgical procedure, but the apparently isolated, small, metastatic nodule in the liver may not be sufficient reason for not removing an operable growth. As a matter of fact, I have seen some extraordinary examples of the length of time, up to 3 and 4 years, that a patient may live with metastasis to the liver after the primary growth has been removed. The circumstances under which resection is advisable in the presence of metastasis are, however, most exceptional; one of these favorable circumstances is present when there is no evidence in the general condition of the patient that the hepatic involvement has progressed to a point at which function is interfered with.

The significance of involvement of the regional lymphatic structures is extremely important in deciding whether or not operation is advisable. The greatest variability exists in the extent and the degree of such involvement. Widespread involvement of the regional lymphatic structures is a very unfavorable prognostic sign. It should never be forgotten, however, that cure is still possible even though the disease has extended into the adjacent lymphatic structures. I have seen many patients who have been cured, but who at the time of operation had such widespread involvement of the lymph nodes that the operation was undertaken as only a palliative measure. Therefore, only one conclusion can be drawn; namely, that with wide removal of the primary growth, but not of all of the involved lymphatic structures, occasionally the patient has enough resistance to the disease to prevent its further extension. This possibility in surgical treatment of carcinoma is worthy of considerable further investigation. The decision as to whether operation is indicated, therefore, will be governed chiefly by the character of the growth itself, because of these known facts, and because of the uncertainty as to whether lymph nodes are involved.

The significance of involvement of the 4 major groups of lymph nodes about the stomach is important, since it has been my experience that the suprapyloric and infrapyloric groups, if involved, are of more serious prognostic significance than those along the greater curvature and the lesser curvature. This is probably because it is more difficult to carry out widespread removal of the former 2 groups of lymph nodes than of the latter. Immediate microscopic examination of a lymph node, if there is widespread enlargement of nodes, is extremely important since a negative report in so far as malignant involvement is concerned is of real significance.

Examination of the growth itself should be most thorough. As has been mentioned before, the patient should be sufficiently relaxed so that there is no interference with maximal mobilization of the stomach. If the patient is straining, the impression may be given that the stomach is fixed because of the advanced disease; an entirely different picture may be given when there is adequate anæsthesia. In this mobilization, the great omentum should be pulled outside of the abdomen. Unfortunately, in many cases, it seems apparent that the growth itself does not permit complete removal because of extragastric extension, but this should be made certain before such a decision is reached. Unless it is clearly apparent that the growth is irremovable, the lesser peritoneal cavity should be widely opened through the gastrocolic omentum to inspect the extent and the character of the posterior perforation. If it is not certain that incurable

penetration of the pancreas has occurred, and if the growth is otherwise removable, resection should be carried out because in many instances the posterior attachment is found to be merely an inflammatory one. If superficial invasion of the pancreas by the malignant disease has occurred, cautery excision of the area may at least give possibilities of cure. Perforation against the under surface of the liver is not necessarily a contra-indication to removal of the growth, since it may be found that what is apparently direct involvement of the liver is only an inflammatory attachment, and if extension of the growth in other directions permits its removal, attachment to the liver should not stand in the way of removal.

If the growth proves to be unattached to the surrounding structures or such attachment does not necessarily interfere with the advisability of resection, examination of the extent of the growth in the stomach is the next step. It is fortunate that carcinoma, except in its extremely late stages, does not extend beyond the pylorus into the duodenum, but this fact is perhaps counterbalanced by the tendency of the disease to progress upward toward and along the lesser curvature rather than along the greater curvature. This feature most often explains inoperability, and also increases the difficulty of thorough removal when the growth is resectable.

A study of the infiltration by carcinoma of the stomach showed, as Cuneo first pointed out, the tendency of carcinoma to extend through the submucous lymphatic structures toward the lesser curvature more rapidly than toward the greater curvature. If, therefore, the carcinoma is of the infiltrating type, examination should be particularly carefully made of the extension upward along the lesser curvature, to detect, as accurately as possible, the limits of this involvement. There, is, however, the very important point in this connection that thickening of the gastric wall should not be confused with carcinoma. Such differentiation of course is not made without difficulty, but the extent of invasion of actual malignancy usually is definite, and it has been my experience that one is more likely to err in saying that thickening in the gastric wall is carcinoma rather than that it is not. Definite involvement of practically the entire lesser curvature is usually a contra-indication to radical operation. The exception, however, is in those rare cases in which the entire stomach is involved in the infiltrating type of carcinoma which results in what is called linitis plastica type; it is in this type that total gastrectomy is most likely to be feasible. Unfortunately, this infiltrating type of carcinoma is most difficult to cure, and it is reasonable to assume a pessimistic attitude toward extremely radical procedures for this type of carcinoma because of the great rarity of cure. On the other hand, the ulcerating or the colloid types of carcinoma are much more clearly demarcated, and microscopic evidences of carcinoma were never found more than 4 centimeters beyond the edge of the area in which there was gross evidence of disease.

One may assume, therefore, when encountering the ulcerative or colloid type of carcinoma, that determination of extension of the disease by palpation is accurate, and if the growth is removable at all, removal can be undertaken without fear of encountering unexpected extension of the disease beyond the point at which it was identified. In the ulcerative and colloid type, the more the growth encroaches on the greater curvature, the greater will be the prospects for removal, because of the relatively easy mobilization of the growth throughout its entire extent; the gastrosplenic omentum can be divided easily and the greater curvature completely mobilized. The largest tumors which may still be operable are of the colloid type. It is extremely important that this fact be kept in mind, because the very size of the tumor may give the impression that it is irremovable and yet resection may be relatively easy to accomplish. A decision as to whether resection is justifiable or not depends also, to a considerable extent, on the type of stomach in which the growth has occurred. In those cases in which the stomach is small and high lying, an infiltrating growth may be clearly inoperable, whereas a similar growth of the asthenic patient with a prolapsed stomach may be operable. Similarly, with the extremely large ulcerating or colloid type of carcinoma, total gastrectomy, or almost total gastrectomy, is

justifiable in certain types of stomach, whereas it would not be reasonable in other types.

If resection seems to be justifiable, there are many variations in the methods by which it may be accomplished. In so far as general principles are concerned, the growth should be removed as widely as possible, gastric continuity should be re-established without undue tension and mechanical function should be perfect. There is no reason, of course, in operations for carcinoma, of the type of operation being adapted to influence gastric chemistry. Detailed description of methods is unnecessary. In a general way, it is advisable that the stomach, after resection, be re-united to the jejunum by one of the many methods advised for this. Re-establishment of continuity, by reuniting the stomach and duodenum following resection, after the Billroth I method, is inadvisable because, if recurrence takes place, it is likely to develop in the vicinity, at least, of such an anastomosis and be responsible for obstruction. The more extensive the resection, the more is an anterior anastomosis between stomach and jejunum indicated. This anastomosis simplifies the operation, is equally satisfactory from the mechanical standpoint, and because of its greater ease of performance, carries a lower mortality rate in dealing with extensive growths. In total gastrectomy there is greater risk of infection than in other procedures and of failure of the anastomosis between œsophagus and jejunum to heal. The properties of healing therefore should be augmented as much as possible by providing for administration of fluids and nourishment by a catheter placed in the jejunum. Rarely is local excision of carcinoma to be preferred, indications for such a procedure are limited to high, well circumscribed growths involving the greater curvature. Excision of such growths, with direct closure, is an excellent method of avoiding operative risk, and of accomplishing just as thorough removal of the disease as by the usual gastrectomy.

So far as palliation by operation is concerned, with the exception of gastric resection, exclusion of the growth is by far the most effective method of bringing about palliation, and I believe there is a much wider application for this operation than it has been accorded. The fact that the growth can be permanently excluded from all contact with food, and gastro-intestinal continuity be made completely independent of the disease, is of great importance, and patients not only live much longer than they live after gastro-enterostomy as a palliative procedure but usually in complete comfort in so far as digestion is concerned. Gastro-enterostomy too frequently fails to accomplish what it is hoped to do as a palliative procedure.

If operation for gastric carcinoma is carried out along the general lines that have been outlined, we have found in the clinic that the rate of operability is approximately 45 per cent, the mortality rate for gastric resection can be kept at approximately 10 per cent. The possibilities of cure of cancer of the stomach are shown by the fact that of several series of consecutive cases in which gastric resection was carried out in the clinic, an average of 18 per cent of the patients are alive and apparently well after operation regardless of the extent of the disease at the time of the resection. If those cases are selected in which the disease is still confined to the stomach, that is, in which there is no lymphatic involvement, the percentage of patients alive and apparently well 5 years after operation is 49 per cent.

FRACTURES OF THE LATERAL CONDYLE OF THE TIBIA CLASSIFICATION, PATHOLOGY, AND TREATMENT[1]

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THE amount of disability caused by a fracture of the lateral condyle of the tibia is very serious because a genu valgum more or less marked is always present and the frequent dislocation of the fragments into the joint cavity and the fragmentation of the meniscus serve to cause a chronic arthritis that steadily weakens the knee joint by softening the ligaments, so that in addition to the limp and deformity of the limb a disabling arthritis is present. We have treated these conditions in various ways—both conservative and operative—and we are certain that fully 40 per cent could be markedly improved with an open operation, because the open operation secures a more even bearing surface and the need of a secondary operation to remove loose fragments of cartilage and bone or fragmented and displaced menisci is obviated. The day is past when an individual with a marked limp or deformity of a limb can obtain employment without a careful inspection, and it is our opinion that in cases in which it is possible to avoid such crippling conditions with an operative procedure, such an operation should be carried out.

When fractures of the tibial condyles are to be considered, it is very necessary to subdivide them into three groups. The first and most common group contains those that involve both condyles; the next, those of the lateral condyle; and lastly, those of the medial, which are the least frequent. Another factor must be considered, and that is that one may have what is actually a double condylar injury, yet the cause of the disability and greatest deformity will be in one or the other condyles. When such a condition is found, it has been our custom to classify the case as either a medial or lateral condylar fracture, depending on the treatment necessary to restore the part to normal.

Quite different problems are encountered in these medial and lateral condyles, and they must be carefully separated when treatment—either conservative or operative—is considered, owing to the marked variations in the pathological conditions present. It is for these reasons that we will discuss in this paper, injuries only of the lateral condyle. These injuries must be subdivided into five types or groups.

After long continued and careful observation of lateral condylar injuries, we are fully aware of the great ability of the knee joint to restore itself to function if given a chance. In some instances, in which multiple other injuries have precluded operative attempts at the correction of condylar injuries—although we were certain of the necessity of such a procedure in order to obtain a serviceable limb—we have been surprised at this efficiency. On the other hand, in some cases which we have attempted to treat with manipulations and casts—feeling that the injury would not justify an open operation—we have later been forced to correct by incision and elevation of the depressed condylar surface.

As in most other fractures, the X-ray pictures cannot be relied upon to tell us with certainty just what should or should not be done. They must be carefully correlated with the deformity and physical findings. It is folly to trust even a provisional diagnosis to anteroposterior and lateral plates, and unless the individual is expert, stereoroentgenograms will be very misleading. In addition, one must have plates taken at quarter angles, anteroposterior and postero-anterior. These six positions, when considered with the physical findings, will give the surgeon a fair idea of what he may encounter in the joint at the time of operation. We have called attention to some of the incorrect inferences that may be drawn from the roentgenograms in the legends, but to impress it firmly requires many more illustrations than space permits in this article.

[1] Work done from the wards of the Cook County Hospital and the Department of Surgery, Northwestern University Medical School

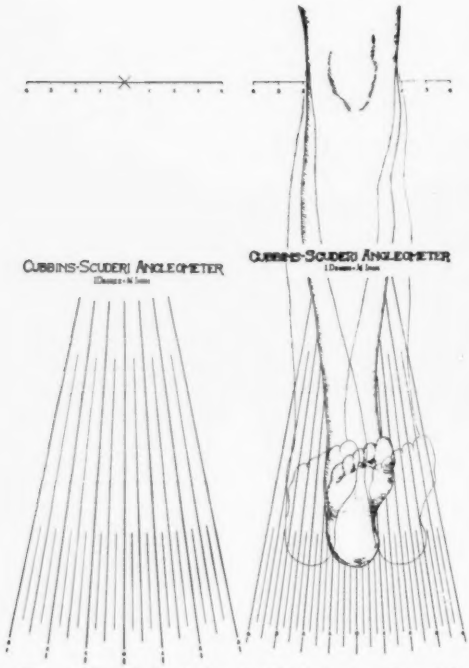

Fig. 1, left. The leg is placed with the knee at *X*, and the heel over the middle line.

Fig. 2. The knee is held firm and the foot moved laterally and medially to determine the degree of angulation.

The common cause of depressed fractures of the lateral condyle of the tibia is the moving front bumper of an automobile striking a pedestrian upon the lateral surface of the extended leg in the vicinity of the knee joint. It does not make any difference if it is a little above, at, or below the articulation. It may also be caused by a fall from a height and many other types of violence. This injury to the lateral condyle may be the only lesion present, or there may also be an avulsion of the collateral tibial ligament from the femoral condyle (Fig. 13), or, what is more rare, a rupture of this ligament opposite the articulation. Occasionally such a force may fracture the lateral condyle of the femur, or fracture both condyles of the tibia or of the femur, or produce a complete dislocation of the knee joint.

SYMPTOMS

The knee joint is always swollen but seldom tender, except over the point of bone or ligament injury. If, in addition to the bone injury, there is a laceration through the synovial lining, this spot is also tender. The patella floats, and there may or may not be discoloration. It is not necessary to elicit crepitus. There is always a marked loss of function, with some deformity, the deformity being a genu valgum of varying degree. The abnormal mobility is the one symptom that presents unusual phases which must be discussed carefully. In those cases with a fragment of the condyle fractured off, or with an even depression of the entire condyle, we find that there is a rather marked valgus and 10 to 30 degrees of lateral motion in the extended leg. In others there will be little if any deformity and a very marked increase in the lateral mobility. Dr. Scuderi designed what we call an angleometer, to show the degrees of deviation (Figs. 1 and 2), and by using a scale of this type, the lateral deviation and the abnormal mobility may be determined in the extended limb. However, while this method will demonstrate these conditions with the limb in a straight angle, it is of no value when the leg is flexed. If the anterior portion of the condyle remains intact and the posterior portion is crushed, there is no increase in the lateral mobility of the extended limb but a marked increase with the limb flexed. If the anterior portion is crushed down, leaving the posterior portion intact, there is very little deformity, only a slight increase in the lateral mobility of the extended limb, but the limb can be slightly hyperextended and the leg rotated inward a small amount. When the posterior portion is depressed (as is seen in Fig. 10), another finding can be elicited which may confuse the examiner—that is, when the leg is flexed 20 to 45 degrees on the thigh and a forward pull is made. The leg rotates forward and inward, just as if the anterior cruciate had been injured. This physical finding is made possible by the fact that the depressed posterior portion of the lateral condyle of the tibia does not impinge upon the condyle of the femur, and therefore permits the extra motion of forward and inward rotation. In order to check this finding, the leg must be extended on the thigh and an attempt made to pull it

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 3. Type 1. Fracture lateral tuberosity—outward displacement—small fragment depressed 1 inch between greater fragments—lateral meniscus displaced down between fragments.

Fig. 4. Joint opened—meniscus removed—small fragment elevated—fixed into position with a screw to make a *flat arch*. This screw should have been made somewhat longer.

Fig. 5. Type 2. Depressed fracture of the lateral tuberosity. Observe that the fragment is displaced laterally, but note that cartilaginous bearing surface is depressed obliquely downward and inward. The meniscus was fragmented.

forward. If the anterior cruciate is intact, no such motion can be produced.

We are cognizant of the fact that if the anterior cruciate ligament was cut in an experimental effort to find this function, and the other ligaments of the knee joint were left intact, no anterior motion would be obtained with a forward pull on the extended leg. But in these cases, with a force that causes an injury to the anterior cruciate, one may rest assured that this anterior cruciate is not the only ligament injured. It is associated with stretching and tearing of many other ligaments.

If there has been simultaneous lesion of the collateral tibial ligament, there will be a point of tenderness and possibly a discoloration at that spot. When the collateral tibial ligament is avulsed or ruptured, in addition to the crushed lateral condyle, lateral motion of the extended leg is always very excessive.

The main points in the pathological anatomy we have stressed in a previous communication, but we wish to repeat those findings here and to classify the injuries of the lateral condyle into five types or groups:

Type 1. Fracture of the lateral condyle. Fragment displaced outward with little if any of the bearing surface depressed (Fig. 3, J.C.).

Type 2. Depressed fracture of the lateral condyle. A large fragment displaced outward and the medial portion of the bearing surface depressed obliquely downward and inward (Fig. 5, Mr. A.).

Type 3. Oblique fracture depression of the bearing surface with only a small portion of the lateral fragment retaining normal level (Fig. 7, F.J.).

Type 4. Fracture depression of posterior portion of the lateral condyle, with forward portion intact (Figs. 8 and 9, W.J.).

Type 5. Fracture depression of the anterior portion of the lateral condyle, with posterior portion intact (Fig. 14, J.F.).

The head of the fibula may be fractured in any of the above types except type 5. If the head of the fibula is fractured in a case involving the lateral condyle, we may be certain that the posterior surface of the condyle has been depressed. The lateral men-

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 6. Meniscus removed. Cartilaginous bearing surface elevated—supported with bone chips from tibia and fastened into a flat arch with a screw. This limb should be held adducted with long lateral splint of plaster for 4 to 6 weeks.

Fig. 7. Type 3. Oblique depression of almost entire bearing surface—meniscus detached and fragmented.

Fig. 8. Meniscus removed—cartilaginous bearing surface elevated with osteotome and supported with bone chips from same tibia. Must be held in adduction.

iscus is commonly torn from its lateral attachment and dislocated between the fragments in type 1. It may also be fractured or fragmented in any of the other types described. Small fragments of bone and cartilage are often encountered in the joint fluid, and we have expressed several from out of the suprapatellar pouch. The fluid in the joint varies in character with the time that has elapsed between reception of the injury and the operative attack. Early it is bloody and filled with clots; later it is not unlike pus, due to the emulsified fat. Free fat drops commonly float on the top of the fluid, and it is remarkable the amount of fat that can be extruded into the joint cavity from a fracture involving only the cancellous bone. The synovia is reddened and discolored by the bloody fluid, as well as being swollen and softened. We have not observed any ruptured cruciate ligaments in these cases, but there have been partial avulsions in several (Fig. 14). As a rule, the lateral condyle is fragmented in a depressed fracture—type 1 being the exception. It may be stated here that the medial condyle is usually fractured off and displaced *en masse*.

TREATMENT

We have encountered about 125 cases of injury of the lateral condyle in the last 6 years, and have operated upon about 50. The others have been treated by molding and casts. Only those that we were fairly sure would cause subsequent trouble have been treated with an open operation. In several which we avoided operating upon, patients subsequently returned and repair was carried out with good results; although as a rule a late repair is more difficult to make correctly than an early repair, and the results are less satisfactory, because we are certain that a long continued mechanical insult can cause a chronic arthritis that will seriously prolong the convalescence.

OPERATIONS

These patients have been operated upon under a tourniquet, following the expulsion of the excess blood from the limb with an elast

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 9. Type 4. Postero-anterior view—bearing surface looks fair.

Fig. 10. Cartilaginous bearing surface depressed down in a curved line. Lateral fragment and the head of the fibula fractured and displaced backward and outward.

Fig. 11. Postero-anterior view—bearing surface correctly elevated. Apparent genu valgum, but none present in clinical examination.

bandage. Vessels that gape should be sought for, caught, and ligated. All patients are carefully tested for bleeding and coagulating time 24 hours before the operative attack. Immediately after and continuing for 6 weeks, the coagulation and bleeding time are very low—2 to 3 minutes; later on, a slow coagulating and long bleeding time may be encountered. The wounds have been closed and dressed before the removal of the tourniquet. No secondary hæmorrhages have occurred in any of these cases.

An incision paralleling the patellar ligament and extending from well above the patella down onto the head of the tibia has been used. This incision we extend farther down over the tibia when it is necessary to obtain bone chips or pegs for the repair of the injury. We have used a large steel screw, such as is used by carpenters and called a wood screw, whenever we were assured that it would best serve the purpose. The screw has the advantage of not needing a drill or preparation, and the deep threads will hold firmly in the cancellous bone, even if the screw is not long enough to perforate the opposite cortex, which is preferable. (See Fig. 11, where a perforating screw has been cut off.) In the other cases we have used bone chips and bone pegs, with heavy catgut sutures, where it is necessary to have additional support (Figs. 6, 10, and 11), but we must discuss the treatment of each type with more detail.

Type 1. A mallet or a redresseur may be used in this type and a fair result be obtained, from both a functional and an X-ray viewpoint, but we have found that to remove the meniscus and accurately replace the fragments has been far more satisfactory, in that an early mobilization may be started and a perfectly functioning joint obtained. Moderate mobilization may be instituted in 1 week with safety, but one must give the soft tissues time to heal firmly before motion severe enough to cause trauma is instituted.

Type 2 (Fig. 5). In this type of case, with the bearing surface crushed obliquely down and a fragment dislocated laterally, no amount of pressure or manipulation can restore the cartilage-covered bearing surface to position. The joint must be opened, the meniscus removed in order to see the lesion, and the bearing surface freed with an osteotome levered into position, braced with

Fig. 12, left. Lateral view—meniscus removed and cartilaginous bearing surface restored to normal—with bone chips and a screw—flat arch method. Notice defects from which chips were taken. Two years later plates showed edges rounded but defects still present.

Fig. 13. Posterior surface of lateral condyle depressed and fibular head fractured—repaired with oblique plates of bone and catgut suture. Also observe exostosis, caused by avulsion of collateral tibial ligament.

fragments from the front of the tibia, and the mass fixed firmly like a flat arch with the screw, which extends across the tibial head. This limb must be fixed in firm adduction in a cast extending from the trochanter down to and including the foot. Mobilization in such cases must be delayed 4 to 5 weeks, because these small fragments must be given sufficient time to become firm (Fig. 6, Mr. A.). If this type of case is operated upon late, it is common to find that the meniscus is displaced, fragmented, and imbedded in among the fragments of the depressed cartilage with a tough, fibrinous material that makes a fairly even bearing surface.

Type 3 (*Fig. 7, F.J.*). This type of injury is best repaired 2 to 3 weeks following its occurrence, in order to allow the fragmented bearing surface to fuse together so that when the surface is elevated they will not be scattered all over the joint. The joint is opened, the meniscus removed, an osteotome 1 inch in width used to free the bearing surface around its circumference over to midline, the depressed bearing surface is then elevated and supported with flat plates of bone from the subcutaneous surface of the tibia (Fig. 8). Mobilization may be initiated in 3 to 4 weeks with other physiotherapeutic agents. The possibility of this type of injury being treated conservatively—with a redresseur or a mallet—is good, but we are inclined to believe that with these methods there is much more likelihood of displacing small fragments into the joint as free bodies. Another factor is that in those cases of this type on which we have operated, the meniscus has always been detached or fragmented, without the peculiar imbedding in the fragments that we have observed in types 2 and 4, and therefor

Fig. 14, left. Type 5. Depression fracture of anterior portion of the lateral condyle bearing surface—with depression—also avulsion of the tibial spines. Fragmentation of meniscus was present.

Fig. 15. Meniscus removed—fragmented depressed bearing surface elevated and supported with chips from same tibia—cruciates in good condition.

may be the cause of much subsequent disability.

Type 4 (*Figs. 9 and 10*). These films show an unusually pronounced depression of the posterior portion of the lateral condyle. This obviously cannot be corrected by any redresseur or manipulation. In this case the incision was made just anterior to the collateral fibular ligament, the depressed bearing surface levered into position and supported with fragments from the tibial crests, and the mass fixed with a screw, as shown in Figures 11 and 12. Please note the change in bearing surface and defects in the tibial crest from which the fragments were removed with an osteotome. X-ray films, made 2 years later, of these tibiæ from which fragments have been removed, show that the defects are not filled in if the patient had reached maturity at the time of operation. In Figure 13 is seen a depression of the posterior surface that has been elevated and held in place with fragments placed obliquely. It also shows an exostosis where the collateral tibial ligament was avulsed and healed back in position without operative treatment. We are convinced that this is the cause of the so called Pellegrina-Stieda disease.

Type 5 (*Fig. 14*). Here we have a depression of the anterior portion of the bearing surface of the lateral condyle and an injury to the tibial spine, which we repaired by elevation of the joint surface, supported with autogenous fragments from the tibia, and made firm with a heavy catgut suture (Fig. 15). The cruciate ligaments were firm and were not disturbed. In this type of case the surgeon must not raise the bearing surface too high or there will be a limitation of extension. However, this is the only type in which excessive elevation is to be avoided. In the 4 other groups we have been trying to raise the lateral bearing surfaces a little higher than normal to avoid a small amount of genu valgum that will remain unless it is elevated somewhat.

CONCLUSIONS

We wish to emphasize the following:

1. The necessity of multiple roentgenographic views taken from all angles.

2. Careful clinical examination in addition to the X-ray views.

The results have been excellent. There have not been any severely infected cases. In only 1 case the screw irritated and had to be removed. There have been no completely ankylosed knee joints. In four young colored men the flexion has been limited to 80 degrees, and one white man has a limitation to 50 degrees, but he would not permit massage or manipulations of any kind and would not help himself. The aged have developed free flexion and extension more rapidly, as a rule, than the young men. This is particularly true of the colored men. There are no women in this series.

There has remained a certain amount of genu valgum in most of these cases, irrespective of how perfect the X-ray picture has been or how well satisfied we have been with the technique. It is less since we have been elevating the posterior surface a little above normal. This work has been done with steel screws with threads cut up to the head, and with ordinary steel screws. The first type is the more satisfactory. We have also repaired these lesions with bone fragments, bone pegs, catgut, and silk. We never use a foreign body—metal or bone—when we can obtain a satisfactory material, whether fascia or bone, from the injured limb of the individual whom we are seeking to benefit.

ARGENTAFFINE TUMORS OF THE TERMINAL ILEUM

A Cause of Intestinal Obstruction

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MASSON'S discovery of the silver reducing properties of cytoplasmic granules in the tumor cells of carcinoids has made it possible for him and his co-workers to carry on extensive researches into the origin and development of these tumors. They have given them the name "argentaffine tumors" and have obtained fairly convincing evidence that these tumors begin with the migration of the Nicholas-Kulchitzky cells from the intestinal mucosa into the neuromata in the wall of the intestine. Raiford recently questioned this mode of development but the work of Masson demonstrates clearly the presence of argentaffine cells inside the nerve fibers. These cells grow very slowly but eventually break through the nerve filaments and invade the surrounding tissue. It seems to us that the only observation lacking is that of actually seeing the living cells as they enter and leave the fibers. Distant metastasis is rare, yet the primary growth often obstructs the intestinal lumen and occasionally metastasizes to the regional lymph nodes. At this stage of development these tumors produce clinical pictures similar to the usual carcinomata and may be mistaken, even during an exploratory laparotomy, for inoperable cancer. Nevertheless, many of the recent authors state that these tumors are of no clinical importance and several good reviews of the literature have failed to consider carefully the clinical manifestations of them.

In order that the clinical significance of argentaffine tumors might be better known and that these seemingly inoperable tumors might not be treated as such, we feel that the following case reports should be presented:

CASE REPORTS

Case 1. T. B., a white woman of 51 years, in January, 1931, first experienced abdominal pains which were similar to labor pains and sometimes lasted for several hours but were most intense in the right lower quadrant. Such attacks of pain recurred at intervals for 1 year during which time the patient became markedly constipated.

Six weeks before admission to the Burlington County Hospital, the abdominal pains became increasingly severe with each succeeding attack yet were not associated with nausea and vomiting. A marked loss of weight had occurred since the onset of symptoms.

The physical examination was negative except for the abdomen which was moderately distended and contained a palpable, hard, non-tender mass, 3.5 centimeters in diameter, in the right iliac fossa. The small intestine proximal to the mass could be felt as a sausage-shaped structure in which peristaltic activity was pronounced. The clinicopathological studies were normal.

Roentgenological studies made by Dr. Borzel revealed an obstructive organic lesion in the terminal ileum which was thought to be of long duration. The colon was normal (Fig. 1).

At operation on February 24, 1932, a small tumor mass was found in the region of the ileocæcal valve. This had produced a partial obstruction of the ileum evidenced by the marked dilatation of the lumen and its greatly hypertrophied muscular wall. Several small, hard lymph nodes were felt in the adjacent mesentery. A tentative diagnosis of carcinoma of the ileum with metastases to the regional lymph nodes was made. An extensive resection was done which included the lower ileum, ileocæcal valve, cæcum, and ascending colon, and then a lateral anastomosis was made between the transverse colon and terminal ileum. The patient recovered without complications and is now free of abdominal symptoms 23 months later.

Pathology. The gross specimen (S. 17,714), after fixation, consisted of 15 centimeters of the terminal ileum, the cæcum with the vermiform appendix, and 15 centimeters of the ascending colon. The angle between the ileum and cæcum in the region of the superior ileocæcal fold was made very acute by a subserous mass which had drawn the anterior surfaces of the cæcum and ileum into close proximity, so that the superior ileocæcal fossa was obliterated. In the areolar tissue of the mesentery and mesocolon at the ileocæcal junction there were four enlarged, firm lymph nodes measuring from 8 to 10 millimeters in diameter. The ileum was dilated to a circumference of 6.5 centimeters, its wall was stiff, and the musculature was markedly hypertrophied.

When the lumen of the ileum and cæcum was laid open, an ulcer measuring 1 by 2 centimeters was found on the postero-inferior surface of the ileum. It extended to within 1 centimeter of the edge of the

Fig. 1. Case 1. T. B., Barium meal fails to pass beyond ileocæcal valve after 24 hours.

lower segment of the colic valve. The base of the ulcer consisted of a protruding tumor mass of very firm, yellow tissue with a slightly roughened surface. The mucosa at the periphery of the ulcer was not lifted up, with resulting overhanging edges, but merged gradually into the tumor. In the mucosa of the cæcum between the left frenulum of the ileocæcal valve and the vermiform process was another ulcer 1 centimeter by 1.5 centimeters which was similar to the one described in the ileum. A section through the specimen made so that the two ulcers lay in one plane showed that both were produced by different parts of the same tumor. The cut surface of the tumor had a yellow color; the muscular coats of the ileum and colon were infiltrated so that the muscular layers were thickened and the bundles were separated by strands of tumor. It had also invaded the subserous tissue, producing thickening and shortening of the fibrous septa. The lymph nodes contained tumor masses similar in color and consistency to the primary growth (Fig. 2).

The remaining portions of the cæcum and ascending colon were normal. The appendix measured 4 centimeters in length and was 1 centimeter in diameter at its middle third. There were no adhesions over the serosal surface. On the anterior aspect of the appendix lying just beneath the peritoneal covering was a small, projecting nodule 2 millimeters in diameter. This nodule was firm, had a yellow color on section, and was clearly a small tumor lying in the outer muscular coat of the appendix with extension into the subserous areolar tissue. The distal four-fifths of the lumen was obliterated by a loose, grayish, translucent fibrous tissue.

Microscopic examination showed that the base of each ulceration was tumor tissue which had also infiltrated the mucosa forming the edges of the ulcer. The line of demarcation was not sharp and in places it was difficult to determine with certainty whether the cells were tumor cells or were epithelial cells forming the intestinal glands (Fig. 3).

The tumor cells were alike in appearance. They were rather small, had poorly defined limiting mem-

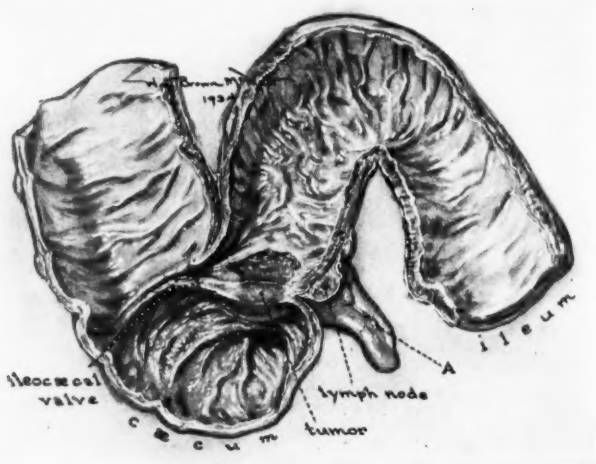

Fig. 2. Drawing of tumor bearing area, Case 1.

Fig. 3. Photomicrograph of section, Case 1.

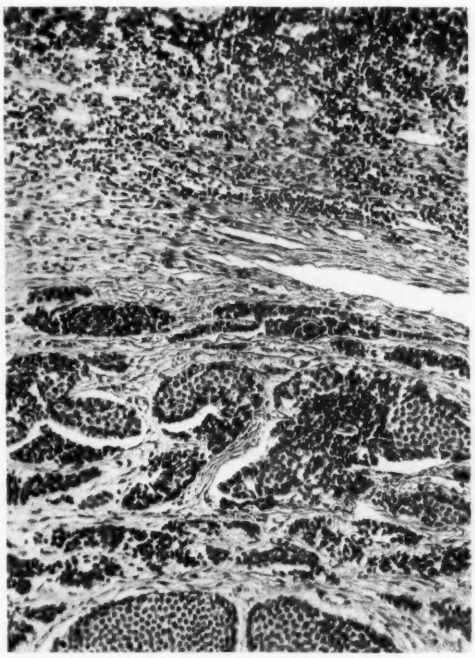

Fig. 4. Photomicrograph of section showing destruction of lymph node by tumor mass.

branes and a cytoplasm which was very finely granular and slightly eosinophilic. The nuclei usually had oval outlines, were vesicular with granular chromatic material distributed throughout. In some nuclei a delicate reticular network was present. The cells were arranged in small masses and cords surrounded by narrow strands of connective tissue stroma through which ran thin walled vascular channels. Interspersed through the larger masses of cells were delicate vascular channels composed of little more than the endothelial lining. The tumor cells encircled these vessels so that pseudo-rosettes were formed, but true rosettes were also present in places.

The tumor invaded the muscular layers of the ileum and cæcum. At those places the musculature appeared thickened and the tumor was accompanied by much fibromuscular stroma. The subserous areolar tissue was replaced by tumor and the sheaths of the nerves in the intestinal wall were extensively invaded by the tumor cells.

A lymph node in the areolar tissue was practically destroyed by a metastatic tumor mass similar in every respect to that in the ileum (Fig. 4).

Silver stains, carried out according to the technique given by Forbus, demonstrated the argentaffine character of the cytoplasmic granules in the tumor cells. Most of the cells were filled with these granules but there were scattered groups which contained only small numbers of such granules and an occasional cell had none. Scattered Nicholas-Kulchitzky cells in the intestinal glands were filled with granules which reduced the silver salts.

The small tumor in the appendix lay in the outer longitudinal muscular layer and was confined to this portion of the wall. Its structure was exactly like the tumor in the ileum and cæcum, an argentaffine tumor probably independent of the larger one since no evidence could be found to indicate that one was a metastasis from the other. The fibrous tissue obliterating the lumen contained many small blood vessels, moderate numbers of lymphocytes, and a few plasma cells. No remnants of mucosa remained and no Nicholas-Kulchitzky cells were in the scar.

Case 2. M. R., a white woman, aged 53 years, a patient in the Department of Nervous and Mental Diseases of the Pennsylvania Hospital, was awakened during the night of February 21, 1932, with acute generalized abdominal pain. A little later she vomited. An effective enema afforded temporary relief, but a few days later the abdominal pain recurred and was accompanied by distention, nausea, and vomiting. Attacks of increasing frequency and severity continued but the pains were never localized. She had no hæmatemesis or melæna at

Fig. 5. Case 2. M. R., Pennsylvania Hospital. Gas and fluid level in the small bowel proximal to obstruction at the ileocæcal valve.

any time but she lost 12 pounds in weight during the month from the onset of the symptoms until her transfer to the surgical service of the hospital.

The physical examination was negative except for abdominal distention and active intestinal peristalsis. The clinicopathological studies were normal. Roentgenological examination by Dr. Bishop showed a marked distention of the small intestines with gas together with many fluid levels. The barium enema did not pass the splenic flexure of the colon (Fig. 5).

At operation a hard mass measuring 1.5 centimeters by 1.5 centimeters by 1 centimeter was found, in the wall of the ileum at a point 10 centimeters proximal to the ileocæcal valve. It infiltrated the wall so that the lumen was greatly reduced. The ileum proximal to the tumor was dilated and had a thickened wall while the portion 10 centimeters distal to the obstruction appeared normal. An enlarged, firm lymph node was present in the adjacent mesentery. Fifteen centimeters above the primary tumor there was another area of thickening and induration in the wall of the ileum.

A provisional diagnosis of carcinoma of the ileum with metastases to adjacent lymph nodes was made.

An extensive resection was carried out during which a portion of the lower ileum with the enlarged mesenteric lymph nodes, the ileocæcal valve, cæcum, appendix, and ascending colon were removed. A lateral anastomosis between the terminal ileum and transverse colon was done. The patient recovered promptly from the operation and has been free of abdominal symptoms for 22 months.

Pathology. The specimen (S. 17,581), after fixation, included 40 centimeters of the lower ileum, with the ileocæcal valve, appendix, cæcum, and 10 centimeters of the ascending colon. There was, in the wall of the ileum 10 centimeters proximal to the ileocæcal valve, a somewhat depressed and puckered area which on palpation was found to overlie a firm tumor mass. This mass measured 1.5 centimeters by 1.5 centimeters by 1 centimeter. It was located in the ventral or anterior portion of the wall of the ileum about 1.5 centimeters from the mesenteric border. The circumference of the intestine was greatly reduced at this level. The ileum above the point of constriction was dilated and had a circumference of 9 centimeters. The wall was firm and the musculature was hypertrophied. The portion of the ileum between the tumor and the ileocæcal valve was normal.

A large firm lymph node, 1 centimeter in diameter, lay in the mesentery in the vicinity of the tumor.

The indurated area which occurred 15 centimeters above the tumor just described proved to be a leiomyoma (Fig. 6).

When the lumen of the ileum and colon was laid open an ulcer measuring 1 centimeter by 1.5 centimeters was seen in the mucosa of the ileum where it overlay the tumor just described. The mucosa forming the edges of the ulcer was not lifted up, but rather merged with the tumor which formed the base of the ulcer. This exposed portion of the tumor had an irregular surface, was of a deep yellow color, and was a little roughened by a thin film of exudate which covered it. A cut made through the tumor and enlarged mesenteric lymph node so that the surfaces lay in the same plane, showed that the dense, yellow tumor tissue had infiltrated the muscular layers of the ileum and was extending out into the subserous fat and that the lymph node was practically replaced by tumor tissue almost precisely like that of the primary growth. No tumor nodules could be found in the appendix.

Microscopic section revealed a tumor composed of rather small cells without very distinct limiting membrane. The nuclei were relatively large, slightly oval in outline, and vesicular in character with chromatin granules lying in the periphery of the nucleus, the central portion being left as a clear zone practically free of chromatin material. Scattered hyperchromatic nuclei were present but no mitotic figures were demonstrated. The cells were arranged in large and small masses in which rosettes and pseudo-rosettes occurred.

The tumor infiltrated the mucosa at the edges of the ulcer so that a sharp transition between these tissues was lacking. The base of the ulcer was composed of tumor tissue in which there was a rather marked inflammatory reaction evidenced by round cell infiltration of the more superficial parts of the tumor and a polymorphonuclear leucocytic exudate covering the ulcerated surface. The tumor cells invaded all of the layers of the intestinal wall bu

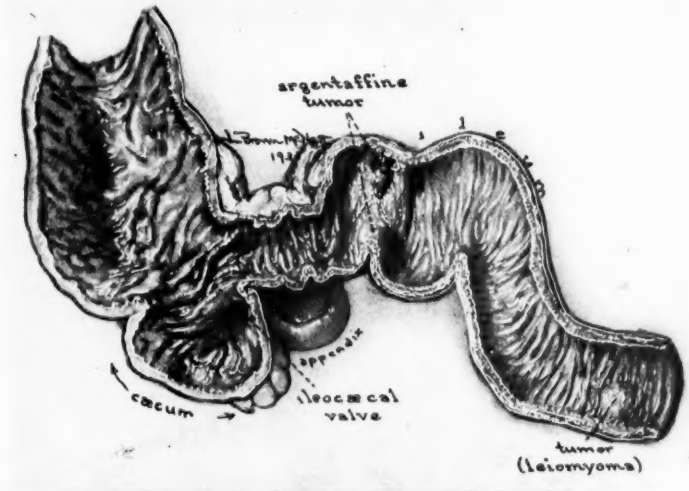

Fig. 6. Drawing of tumor areas in Case 2.

the greater portion of the tumor lay in the position previously occupied by the mucosa, submucosa, and muscularis mucosæ.

The mesenteric lymph node was hardly recognizable due to the replacement of its structure by tumor similar to that described in the wall of the ileum. There was relatively more stroma in the metastasis than in the primary tumor. The stroma cells were small, usually spindle shaped, and were compactly arranged in dense bands separating the masses of tumor cells. There was little or nothing to suggest the presence of smooth muscle cells in the metastasis.

Silver stains showed that there were large numbers of argentaffine granules in a great proportion of the tumor cells. The Nicholas-Kulchitzky cells in the intestinal glands were well stained and occurred frequently.

Argentaffine tumors resemble carcinomata in that they invade tissues locally, and extend into the regional lymph nodes. They may be differentiated from the usual carcinomata by their yellow color, firm consistency, the absence of necrosis, lack of mitosis in the tumor cells, and the ability of the cytoplasmic granules to reduce silver salts.

Practically all of the cases of metastasizing carcinoids have shown signs and symptoms of mild intestinal obstruction over relatively long periods before the terminal stages of cachexia and death ensued. Both of our cases presented evidence of rather marked obstruction and had metastases in lymph nodes. Ewell and Jackson's patient had obstructive symptoms without metastases. Their patient underwent operation successfully and was well 2 or more years after extirpation of the tumor. Stewart and Taylor's patient with a carcinoid of the appendix and metastases to the pelvis was well 10 years after removal of the original tumor and metastases.

The excellent results obtained in these cases lead us to feel that it is very important to diagnose argentaffine tumors correctly at operation since removal of the tumors with their metastases offers a highly favorable prognosis.

BIBLIOGRAPHY

EWELL, G. H., and JACKSON, R. H. Carcinoid tumors of the small intestine; with case report. Wisconsin M. J., 1931, xxx, 737.

FORBUS, W. D. Argentaffine tumors of the appendix and small intestines. Bull. Johns Hopkins Hosp., 1925, xxxvii, 130.

GOSSET, A., and MASSON, P. Tumeurs endocrines de l'appendice. Presse méd., 1914, xxii, 237.

RAIFORD, T. S. Carcinoid tumors of the intestinal tract. Am. J. Cancer, 1933, xviii, 803.

STEWART, M. J., and TAYLOR, A. L., Carcinoid tumour of appendix and large pelvic deposits. J. Path. & Bacteriol., 1926, xxix, 136.

SUBTOTAL RESECTION OF THE PANCREAS FOR HYPOGLYCÆMIA

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THE recent interest in chronic hypoglycæmia as a surgical problem has now in enough cases resulted in the successful removal of an adenoma of the islet tissue of the pancreas with the restoration of the amount of blood sugar to a normal level to include this condition definitely in the group of those affections which are amenable to surgical therapy. A review of the reported cases up to December, 1932, has been given in one of our former articles. Since preparing that article adenomata have been removed successfully in 2 more cases at the Barnes Hospital, making a total of 5 successful cases at that hospital alone, and several other cases have been reported by various authors. It is impossible, however, to diagnose accurately the presence of an adenoma even when attempts have been made to exclude other causes of the low blood sugar, such as a disturbance of the glycogenic function of the liver, a failure of the adrenal glands to secrete the proper amount of adrenalin, and disorders of the pituitary. The literature contains records now of several cases in which, because no tumor of the pancreas was found at operation, a portion of the apparently normal pancreas was removed. For example, portions of a normal appearing pancreas have been removed by the Finneys, by Holman and Railsback, by Judd and his collaborators, and by Harris and Taylor. In a recent article Judd, Allan, and Rynearson have summarized the experience at the Mayo Clinic in operating on 8 patients for a supposed adenoma of the pancreas. In 4 of these cases, segments of various sizes were removed from the pancreas because of failure to find the expected tumor. The results were not particularly striking in any of their cases and the patients still continued to have hypoglycæmia. One of these cases is particularly interesting because it is the patient from whom Holman about 4 years previously had removed about one-half of the pancreas because of failure to find an adenoma. At a later operation performed by Judd only a small nodule was removed from the remaining portion of the pancreas and there was no marked change in the patient's condition. The case had been previously reported by Holman and Railsback as having been slightly improved. Evidently the improvement was not sustained. In the Finneys' case approximately two-thirds of the pancreas was removed, beginning at the tail. There was no noteworthy improvement in the patient's condition after the operation. In a personal communication, Dr. Seale Harris has written that, in a patient operated upon by Dr. Adrian Taylor, a clinical cure was accomplished by the resection of about half the body and all of the tail of the pancreas except the portion attached to the splenic vessels.

It becomes evident from this brief review of the reported cases that in general the resection of an approximately normal pancreas up to the amount of two-thirds of it is not likely to result in permanent improvement of the chronic hypoglycæmia except rarely. Several authors have drawn an analogy between the condition of so called hyperinsulinism with hypoglycæmia and hyperthyroidism with its effects. The argument has, therefore, been made that removal of some of the pancreas should have just as much effect in the relief of hypoglycæmia as does the removal of part of the thyroid gland in cases of thyrotoxicosis. This idea was originally expressed by Wilder and has since been mentioned by many authors who have written on the subject of the application of surgery to hypoglycæmia. If it should prove true that there is such a condition as hyperinsulinism associated with a pancreas which is relatively normal anatomically then it would seem apparent that the removal of a considerable portion of the pancreatic tissue would probably improve the state of hypoglycæmia. In line with such reasoning one might suppose that the failure to obtain permanent and satisfactory results

in the majority of cases in which a true tumor has not been found might have been due to the removal of too little pancreatic tissue. It is well known, for example, that it is necessary to remove from the normal dog approximately 80 per cent of the pancreas in order to create a state of diabetes. Likewise it will be recalled that surgery in toxic thyroid disease remained on the whole unsatisfactory until it became generally recognized that it was necessary in most cases to remove nearly all of the thyroid gland.

With these considerations in view the following case seems to be of interest and importance because of several features. Owing to a failure to find a suspected adenoma, a subtotal resection of the pancreas was performed in which all of the pancreatic tissue was removed except for a very small portion which was allowed to remain in order to protect the common bile duct. It was estimated that between 80 and 90 per cent of the pancreatic tissue was removed. The result of the removal of this amount of pancreatic tissue was a prompt improvement in the persisting chronic hypoglycæmia, and this improvement has been maintained over a period of 9 months. Another unusual feature about this case is that it is the youngest patient, reported in the literature, who has been subjected to an operation for a supposed adenoma of the pancreas (1 year of age). Apparently also it is the first time that a deliberate attempt has been successfully carried out to remove practically all of the pancreatic tissue. Another striking feature of the case has been that the correction of the state of hypoglycæmia in the patient has permitted the baby to develop from a patient with a markedly retarded mentality to one with a mentality so developed that the parents consider her to be a normal child.

The patient was admitted to the St. Louis Children's Hospital on May 9, 1933, at the age of 12 months, because of convulsions. The admitting note was as follows: "The baby was a full term spontaneous delivery without difficulty. The birth weight was 9 pounds; perfectly well until the age of 3 months when she had a mild convulsion involving only the arms and chiefly the right arm. At 7 months she had another convulsion which was more severe and began in the right leg with progression to the right arm and right face. Yesterday there was a series of six convulsions mostly on the right side.

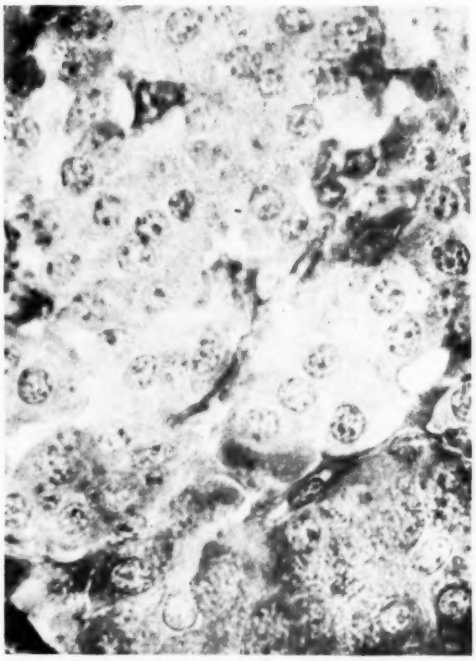

Fig. 1. Section of pancreas removed showed no neoplastic growth.

The majority of these convulsions lasted from 2 to 4 minutes but one lasted for nearly an hour. The blood calcium which was determined at the request of Dr. H. W. Gante of Anderson, Indiana, when the patient was 11 months of age was found to be low (4.3 milligrams per 100 cubic centimeters of serum) and since that time she has been taking calcium gluconate by mouth. She has been able to hold her head up slightly since the age of 2 months but she does not sit up, walk or talk."

Examination showed a cheerful, fat, flabby, hypotonic baby. The head appeared somewhat larger than normal. The fontanelle was very widely open but not bulging. Four incisor teeth were present. The reflexes were equal and active. The patient would not hold up her head for more than a very brief moment. On May 12, her fasting blood sugar was 19 milligrams per cent, expressed as true glucose. A glucose tolerance test showed a rise of 60 milligrams per cent in 1 hour with a fall of 40 milligrams per cent in 2 hours. Several other determinations of the fasting blood sugar showed a marked hypoglycæmia.

On May 17, Dr. Sidney I. Schwab, after a neurological examination of the baby, made the following note: "This is a hypoglycæmic child with convulsions. No neurological basis for the convulsions is found. In the hypoglycæmic state the patient ap-

TABLE I.—BLOOD SUGAR VALUES OBSERVED DURING PERIODS OF STUDY AND TREATMENT

Period I (May 9–13) (June 1–12) Regular diet—no treatment			Period II (May 13–31) High carbohydrate diet			Period III (June 13–25) Regular diet—pituitary extracts			Period IV (July 10 and subsequent) Postoperative		
Date	Hrs. after food	Glucose mgm. per 100 c.cm.	Date	Hrs. after food	Glucose mgm. per 100 c.cm.	Date	Hrs. after food	Glucose mgm. per 100 c.cm.	Date	Hrs. after food	Glucose mgm. per 100 c.cm.
5–10–33	3	45†	5–15–33	4	47*	6–14–33	3½	40*	7–10–33	2:05 p.m.	522*
5–11–33	4	23†	5–15–33	1½	83*	6–14–33	4½	20*	7–10–33	3:55 p.m.	448*
5–12–33	3	19*	5–16–33	2	110*	6–14–33	1	33*	7–11–33	3	502*
5–13–33	3¾	6*	5–16–33	2	229*	6–15–33	3	40*	7–11–33	2	471*
			5–15–33	2	127*	6–15–33	1	33*	7–12–33	3	318*
6– 1–33	3½	55*	5–16–33	1	201*	6–15–33	2½	31*	7–12–33	1¼	205*
6– 2–33	3½	33*	5–17–33	2	93*	6–19–33	3½	23*	7–13–33	4	126*
6– 8–33	2	32*	5–17–33	2	127*	6–19–33	4½	24*	7–13–33	1½	140*
6– 8–33	4	23*	5–18–33	2	43*	6–19–33	1¼	25*	7–14–33	3½	82*
6– 9–33	2	18*	5–18–33	2	47*	6–20–33	3½	23*	7–15–33	3¼	125*
6– 9–33	4	25*	5–19–33	2	68*	6–20–33	4½	28*	7–17–33	2	88*
6–12–33	4	25*	5–19–33	2	136*	6–20–33	1¼	30*	7–18–33	1½	159*
			5–22–33	2	104*	6–22–33	3½	10*	7–18–33	3¾	130*
			5–24–33	1½	63*	6–23–33	3½	19*	7–19–33	3½	103*
			5–27–33	3½	46*	6–24–33	3½	32*	7–21–33	2¼	59*
						6–25–33	3½	12*	7–22–33	3	85*
						7– 3–33	4	57*	7–24–33	3¼	87*
						7– 5–33	3¾	46*	7–27–33		82*
									8– 2–33	3¼	110*
									8–30–33	3¾	61*
									8–31–33	2	86*
									9– 1–33	3¾	67*
									9– 1–33	3½	102*
									9–26–33	3½	69*
									9–28–33	3½	73*
									9–28–33	2¼	77*
									10–3–33	3½	63*
									10–5–33	3½	90*
									4–19–34	4	83*

*Capillary whole blood "true" sugar values.
†Venous whole blood "apparent" sugar values.

pears dull and lethargic and gives the impression of mental deficiency or backwardness. When the blood sugar is near or beyond the normal after feeding of carbohydrates the patient becomes more alert, appears brighter, holds her head up, and can almost sit alone. This would seem to establish in my opinion the relationship between the hypoglycæmia and the convulsions and the mental state."

On several occasions in the hospital the patient had convulsive attacks which were sometimes chiefly present on the right side but sometimes also most marked on the left side. In some of the attacks she apparently became unconscious. Prompt relief was regularly obtained by giving orange juice by gavage.

Before a decision was made to look for a pancreatic tumor, the patient was studied from a number of angles. The observations may conveniently be divided into a number of periods, as follows (see also Table I):

1. Initial observations: During this first period of study, the patient was kept on an ordinary infant diet, suitable for a baby 12 months of age. Du-

TABLE II.—GLUCOSE TOLERANCE TESTS BEFORE AND AFTER OPERATION

Date	Time	Blood sugar mgm. per 100 c.cm.	Remarks*
5-12-33 Before operation	12 50 p.m.	19.0	19.0 gms. glucose (1.75 gms. per kilogram body weight) given in 150 c.cm. dilute orange juice at 12:50 p.m.
	1:30 p.m.	39.0	
	2:30 p.m.	43.0	
	3:30 p.m.	61.0	
	4:30 p.m.	42.0	
4-20-34 After operation	8:55 a.m.	39.6	17.5 gms. glucose (1.75 gms. per kilogram body weight) given in 150 c.cm. dilute orange juice at 8:55 a.m.
	9:35 a.m.	89.5	
	10:05 a.m.	106.4	
	11:05 a.m.	99.8	
	12:05 p.m.	47.7	

*The apparent discrepancy in the statement here that the body weight was greater on May 12, 1933, with the statement in the text that the child gained 6 pounds between her discharge from the hospital and the examination on April 20, 1934, is to be explained by the fact that there was an actual loss of weight during the child's stay in the hospital because of several infections.

TABLE III.—RESPONSE OF BLOOD SUGAR TO EPINEPHRINE BEFORE OPERATION

Date	Time	Blood sugar mgms. per 100 c.cm.	Remarks
6-29-33	8:50 a.m.	32.0	3 minims adrenalin chloride given subcutaneously at 9:00 a.m.
	9:20 a.m.	67.0	
	9:42 a.m.	84.0	
	10:04 a.m.	99.0	
	3:25 p.m.	57.0	
6-30-33	8:50 a.m.	59.0	3 minims adrenalin chloride given subcutaneously at 8:55 a.m.
	9:24 a.m.	104.0	
	9:46 a.m.	114.0	
	10:08 a.m.	113.0	
	10:35 a.m.	113.0	
	11:03 a.m.	113.0	

ing this period, which lasted a week or so, she had several convulsions, often seemed very drowsy, was rather hypotonic most of the time and generally impressed one as being mentally deficient. Routine physical and laboratory examinations revealed nothing of importance except for the blood sugar concentration. The Wassermann and tuberculin reactions were negative. Schick test was positive. The urine was normal, the blood count and smear within normal limits. Her serum calcium was 12.0 milligrams per 100 cubic centimeters, serum inorganic phosphorus 5.0, non-protein nitrogen 23.0, protein 7.1 per cent. The initial blood sugar, however, was 45.0 milligrams per 100 cubic centimeters (non-true sugar value). The following day it was 23.0 milligrams per 100 cubic centimeters. Two days after admission, a glucose tolerance test was made (see Table II). During the next few days blood sugar determinations were repeated and true sugar values on capillary whole blood were usually under 30.0 milligrams per 100 cubic centimeters, and on one occasion the extremely low value of 6.0 milligrams per 100 cubic centimeters was obtained.

2. During this period, the effect of a high carbohydrate diet was studied. In addition to her regular infant diet with milk feedings at 4 hour intervals she was offered in between each milk feeding orange juice with added sugar, the idea being to keep up constant absorption of dextrose from the intestinal tract. During this period the blood sugar rose distinctly, but in general remained still slightly subnormal. This rise in blood sugar was accompanied by improvement in the appearance of the patient, convulsions ceased, she seemed somewhat more alert, she sat up by herself and the nystagmus, which had been present from time to time, remained absent for long periods of time. At the beginning of the study she developed a respiratory tract infection, accompanied by fever. Associated with this infection, there was a rise in the blood sugar to 229 milligrams per 100 cubic centimeters, accompanied by a transient period of glycosuria. After recovery from this infection, the blood sugar again returned to a subnormal level.

3. During this period we investigated the effects of several pituitary extracts which were thought might contain substances tending to raise the blood sugar level. Loeb's thyrotropic pituitary hormone was used, as well as Collip's thyrotropic pituitary hormone, and the growth hormone of Parke, Davis and Company. Despite the injection of what presumably was a large amount of such substances, no real effect on the blood sugar level was determined.

4. During this period we investigated the glycogenic function of the liver. Adrenalin was injected subcutaneously and the blood sugar followed for a number of hours afterward (see Table III). Adrenalin was quite effective in bringing the blood sugar up to a normal value and holding it there for several hours. At this stage of the study it was felt that it was extremely advisable to explore the pancreas in the hope of finding a tumor.

On July 10, 1933, the patient was operated on (by E. A. G.) through an upper left paramedian incision. The pancreas was exposed without difficulty through the gastrocolic omentum. Nothing resembling a tumor was seen or felt. Exploration of the rest of the abdomen revealed nothing abnormal. Both adrenal glands were felt to be normal in size. The liver also seemed normal. It was, therefore, decided to resect most of the pancreas. The tail was mobilized easily and it was stripped from the splenic vessels without difficulty except for the ligation of five or six small veins which were tributary to the splenic vein. Almost a complete removal of the pancreas was accomplished leaving only a small remnant of pancreatic tissue in the curve of the duodenum to protect the common bile duct. The amount of pancreas which was allowed to remain was estimated at less than one-eighth of the total amount. The resection of the pancreas was accomplished with surprising ease. A rubber dam drain was placed next to the stump of the pancreas and it was brought out through a stab wound. The incision was closed in layers.

Following the operation, the patient developed a blood sugar of 522 milligrams per cent, and, of course, had glycosuria. The hyperglycæmia gradually

diminished, and finally a true sugar value which remained fairly constant around 80 milligrams per 100 cubic centimeters (which is normal) was attained. During this time there was some trouble as the result of a wound infection. Persistent otitis media also made it necessary to do a bilateral antrotomy. During her recovery from the wound infection and the mastoid operation, she lost most of her flabby fat. During this time her blood sugar remained normal. It seemed to us that she appeared a little bit more intelligent and noticed things about her more. Intelligence tests, however, as conducted by an expert, Miss Barbara Kendall, failed to reveal any improvement over several months' time. She commented as follows: "Perhaps it is too much to expect a change until the patient is put in a more stimulating environment and until she has fully recovered from the effects of her recent illnesses." The patient was discharged from the hospital on October 22, 1933.

Examination of the pancreas. The removed pancreatic tissue was given immediately to Dr. James L. O'Leary for examination. Dr. O'Leary, of the department of cytology, is a former pupil of Dr. R. R. Bensley of the University of Chicago and is familiar with all of Bensley's special methods of examination of the pancreas for secretion granules. Dr. O'Leary's report of his examination follows:

"The material received for diagnosis consisted of a portion of the pancreas of a child of 11 months which had been removed by Dr. Evarts Graham and associates 10 minutes previously. It appeared normal to gross inspection, contained no palpable masses.

"Blocks were fixed immediately in aqueous, acetic (5 per cent) and formol (10 per cent) chrome sublimates, in acetic-osmic-bichromate (Bensley's fluid), in formalin-potassium bichromate (Regaud's fluid) and in picro-acetic-formol (Bouin's fluid). Several snips were placed immediately in Ringer's fluid and in 1:2000 neutral red in physiological saline for fresh examination.

"Islet cells were isolated by teasing bits of fresh pancreatic tissue, the bits were mounted between slide and coverslip and studied with an oil immersion lens. The islet cells thus examined in the fresh, unstained state appeared normal. In the material immersed in neutral red, it was found that the specific cytoplasmic granules of all islet cells, which had ready access to the dye, colored. No differentiation between A and B cells was apparent.

"Five micron sections from the formol chrome sublimate blocks, after dehydration, imbedding and cutting, were stained by the Mallory azan method and with aniline acid fuchsin-Mallory II. The slides stained by the latter method received a preliminary treatment with potassium permanganate and oxalic acid. Sections from blocks fixed in formalin, acetic and aqueous chrome sublimates were stained with Bensley's and Bowie's neutral dyes.

"The acinar and duct components of the pancreas may be dismissed with the statement that detailed examination revealed no abnormal characteristics. A complete survey by the section method of the pancreas removed showed no evidence of neoplastic growth. (Fig. 1.)

"The appearance of the islets was considered in more detail by comparison with a series of similarly fixed critical specimens. The series included: (1) two normal adult pancreases obtained at necropsies performed shortly following accidental death; (2) the pancreases of two adult patients having symptoms of chronic hypoglycæmia (these were obtained through the courtesy of Dr. Nathan Womack, St. Louis, who removed about one-half of the pancreas in each case with subsequent alleviation of the hypoglycæmic symptoms); (3) a case of hypertrophy of the islets of Langerhans in the newborn examined through the courtesy of Dr. S. H. Gray, St. Louis; and (4) a series of slides demonstrating hydropic degeneration in the islets of the cat's pancreas during the course of experimental diabetes produced by the removal of seven-eighths of the organ. The latter were representative of the material used by Homans (1914, J. Med. Research, 30) in his extensive study of experimentally produced hydropic degeneration. They were loaned to us by Dr. R. R. Bensley.

"As far as could be judged from thin sections, the islets occurred in normal size and number. A, B, and D cells occurred in the normal order of frequency. They usually had closely packed specific granules; but, not infrequently, cells were observed which had a sparsity of granules. Occasional cells were found which had pyknotic nuclei and dense cytoplasm containing numerous vacuoles of varying size. These did not resemble those found in the condition called hydropic degeneration.

"In contrast to the portions of the pancreases obtained through the courtesy of Dr. Womack, and critical normal control material, the majority of the islet cells after formol chrome sublimate fixation, contained no vacuoles. In the material used for purposes of comparison, normal appearing islet cells of both alpha and beta varieties were frequently found which contained two to three, sometimes five or more small vacuoles scattered through the cytoplasm.

"In the islets of the present case there were a slightly larger number of degenerating cells than are usually found in the islets of normal pancreases although it is questionable whether or not this observation has any particular significance."

RE-EXAMINATION OF THE PATIENT 9 MONTHS AFTER OPERATION

On April 19, 1934, the patient returned for examination. The mother stated that there had been no convulsions and no repetition of any of the former symptoms of hypoglycæmia. The most significant finding in the examination was a true blood sugar value of 83 milligrams per 100 cubic centimeters in the fasting

state, a practically normal amount. The remainder of the blood chemical studies showed the following: Serum carbon dioxide content 53.7 volumes per cent, serum protein 8.06 per cent, sodium chloride 620, non-protein nitrogen 27.0, and inorganic phosphorus 6.1 milligrams per 100. The baby had developed physically to a gratifying degree. She had lost her flabby appearance, she was able to sit up without difficulty but was still unable to stand without holding to something. Her nutrition was normal. She had sixteen teeth. The fontanelles were closed. The stools were normal and on microscopic examination showed no abnormal deficiency in the digestion of starch or fat. Her weight was 25.5 pounds, a gain of 6 pounds in the 6 months since her discharge from the hospital. The mother felt convinced that the baby was normal mentally for her age of 23 months. She took a marked interest in toys, responded to her name, and said three or four words. A re-examination of the patient, however, by Miss Kendall failed to show as much definite evidence of gain in mental development as seemed probable. Her conclusion is as follows: "The intelligence quotient of 52 represents a gain of 15 points over the rating of 37 (the previous rating), or a gain of 7 months since October. It is impossible to foresee whether a further gain in intelligence quotient is to be expected."

CONCLUSIONS

A case is reported in which between 80 and 90 per cent of the pancreas was removed from a baby 1 year of age for chronic hypoglycæmia with repeated convulsions and a marked retardation in mental development.

The blood sugar, although at first raised to an abnormally high level as a result of the removal of so much pancreatic tissue, later became practically normal in amount. All of the symptoms caused by the hypoglycæmia promptly disappeared and have not recurred.

The mental and physical states of the patient have shown marked improvement since the operation, but it is too early to determine whether the mental development of the baby, perhaps retarded by the persistent hypoglycæmia, will progress to the state of a normal child.

The pancreatic tissue which was removed was essentially normal anatomically. It is impossible, therefore, to state whether the hypoglycæmia in this case was due to hyperinsulinism or to some other factor. The other known causes of hypoglycæmia were apparently satisfactorily excluded.

This case differs from other cases in which portions of apparently normal pancreas were removed for hypoglycæmia in that in this case a much larger proportion of the organ was removed, amounting actually to a subtotal resection.

No interference with the general nutrition of the baby or of the acid-base balance of the blood occurred as the result of losing nearly all of the pancreatic tissue.

REFERENCES

FINNEY, J. M. T., and FINNEY, J. M. T., JR. Resection of the pancreas. Ann. Surg., 1928, lxxxviii, 584.

GRAHAM, E. A., and WOMACK, N. A. The application of surgery to the hypoglycæmic state due to islet tumors of the pancreas and to other conditions. Surg., Gynec. & Obst., 1933, lvi, 728.

HOLMAN, E., and RAILSBACK, O. C. Partial pancreatectomy in chronic spontaneous hypoglycæmia. Surg., Gynec. & Obst., 1933, lvi, 591.

JUDD, E. S., ALLAN, F. N., and RYNEARSON, E. H. Hyperinsulinism: its surgical treatment. J. Am. M. Ass., 1933, ci, 99.

PASSIVE VASCULAR EXERCISE IN THE TREATMENT OF PERIPHERAL CIRCULATORY DISEASE[1]

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IT is one of the most trite of medical axioms that a man is as old as his arteries. The gradual lessening of blood to the tissues is the mechanism that carries us farther and farther away from the glory of youth.

When this lessening of blood supply takes place very gradually and involves most of the tissues of the body simultaneously, we accept it with more or less resignation. It is only when some particular part is involved sharply, or when the change in blood supply occurs earlier than the average age expectation that our attention is especially arrested.

That this alteration in blood supply is inevitable and is the cause of the great involution in the body is a part of our common knowledge. We look upon it as one phase of our biological heritage. Why certain tissues are involved out of all proportion to the remainder of the body, or why these changes should occur as a pre-senile process, arouses in the student of pathology and therapeutics a curiosity that is on the increase. Through observation and experiment a very great impetus has been given to the study of the etiology of impaired circulation, and in recent years much has been written regarding prevention and treatment.

From a surgical standpoint, we are chiefly concerned with the circulation of the extremities—the problems of peripheral circulatory disease—but whatever the structure involved, the causes, the damage, and the principles of treatment are the same. Coronary thrombosis, interstitial nephritis, atrophic cirrhosis, and anæmia of the central nervous system, are brothers to peripheral vascular disease. We cannot see these deeper structures so plainly nor can we approach them so easily and that makes the difference.

We have been passing through a phase of active operative therapeutics in the treatment of these conditions. Reversal of the circulation, balancing the circulation, ligation of the main artery, arterial sympathectomy, and ganglionectomy were thought out and courageously tried, for there is much to gain and little to lose in fighting for the life of a limb already doomed. In the last analysis amputation is a confession of failure, but it is often a method of relieving the patient's symptoms and sometimes prolongs his life.

At the present time there is a tendency to urge earlier diagnosis and conservative treatment rather than wait until some form of necrosis or infection has occurred. A very considerable literature has accumulated and the authors are stressing a number of factors. The lessening in blood flow is due to two chief causes, spasm and organic narrowing of the vessels. The development of collateral circulation is the means by which improvement in circulation is, for the most part, brought about. Landis and Gibbon have shown by experiment and observation that suction applied to a limb sharply increases the blood supply.

Morton and Scott worked out and standardized a method of estimating the relative parts played by angiospasm and organic narrowing of the vessels in this group of peripheral vascular diseases. Their reports have done a great deal in clearing up a field of therapy in which thought and practice were often cloudy and confused. Pearse has recently reported the experiences of the surgical clinic at the University of Rochester with vein ligation as a means of increasing the amount of blood in an extremity.

In this paper we do not propose to discuss the various operative procedures that have been tried and are still being used, but shall confine ourselves to a report of our experiences with passive vascular exercise.

During the past 25 years, and following upon the pioneer work of Leriche, there has been a gradually increasing interest in the study of peripheral vascular disturbances and a broadening conception of the entire field. Attention and thought and trial were quickened by the

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work of Royle and Hunter in 1924. This was particularly true of the sympathetic nervous system, especially in its relation to the control of blood supply and to pain.

Upon the footsteps of this initial enthusiasm and its reaction, and because of so many disappointments, there has gradually developed a more rational evaluation of all therapeutic measures at our command in the treatment of the various disturbances of the peripheral circulation.

Along with this rational evaluation of therapeutic measures there has developed also the better method of treating each case as an individual problem rather than trying to apply a mass rule. Encouraged by some successes and despite many disappointments, surgery is beginning to show a resoluteness of purpose that has not before been seen in this particular field.

In 1834 Junod presented to the French Academy of Sciences his experience with the application of "thinned and thickened air," either to the entire body or to a single portion of it. The apparatus used, and which was known as Junod's boot, consisted of a glass and copper cylinder or boot shaped to fit the foot and leg. A broad rubber ring was fastened about the extremity to shut off air. A manometer and thermometer were supplied and the boot was attached to a suction syringe and, if needed, heated vapors were also applied.

At that time the observation was made that "if the atmospheric pressure over an extremity is diminished the skin swells and becomes red and the limb soon increases in circumference. The inflowing blood spreads an unaccustomed warmth in it; the exerted moisture quickly evaporates and deposits on the walls of the cylinder." The work of Junod did not gain wide recognition and was forgotten.

In 1905, August Bier introduced the principle of hyperæmia as a therapeutic measure. His work was followed with great interest and his methods, although they were often modified, were widely used. He stated that, "if we accept the reactions of the body as useful efforts of nature, we must admit that hyperæmia is the most widespread of all autocurative agents."

Bier used a glass boot with a cuff of para paper for its attachment. The boot was hooked up to a bicycle pump and the valves changed so as to convert it into a suction pump. He noticed an increase of surface temperature following treatment. Experience taught him that dilatation of a certain area of capillaries is associated with an acceleration of blood current in the concerned area, provided the heart action remains the same. He also noted that in the development of collateral circulation by hyperæmia, produced by dilatation of the vessels, it was the capillaries that played the active rôle. A modification of this method was used by Willy Meyer and Schmeiden and Klaff in disturbances of the circulation of the extremities. Sinkowitz and Gottlieb in 1917 reported excellent results in 4 cases of thrombo-angiitis obliterans.

In December, 1933, Reid and Herrmann presented before the Southern Surgical Society, a preliminary report of the results of a negative pressure environment in the treatment of occlusive peripheral vascular disturbances. The apparatus used was named the pavaex, which is an abbreviation for "passive vascular exerciser." It mechanically supplies an alternating negative and positive pressure environment.

In January, 1934, Reid (11) presented a more complete and detailed report of its uses in the Matas Vascular Surgery Lecture. Several years ago the same writer, in a paper read before the American Surgical Association, (10) made a strong plea for early and conservative treatment, and as a result of the excellent work done by Reid and Herrman a tremendous impetus has been given to the conservative management of peripheral vascular disturbances.

It is on the basis of their work that the following series of cases is presented. First, as confirmatory of their results, and second, with the view of suggesting that such a method has great possibilities as a therapeutic measure, not only in thrombo-angiitis, arteriosclerosis, and the various occlusive diseases, but also in ununited fractures, arthritis (atrophic and hypertrophic), frostbite gangrene, and the various circulatory disturbances that result from trauma.

THROMBO-ANGIITIS OBLITERANS

CASE 1. H. J., white, aged 61 years, had had symptoms referable to the left lower extremity for 1 year. The skin surface was glistening with dusky discoloration; the foot and toes were held immobile; there was œdema of the entire dorsal surface of the foot and all of the toes; exquisite tenderness was noted. He was unable to stand any form of pressure. No pulsation was obtained in the dorsalis pedis and posterior tibial arteries. Following an intensive course of treatment over a period of 2 months, subjective symptoms disappeared. Along with this there was a gradual subsidence of the œdema and discoloration. At the present time, 4 months after treatment was begun, there is no recurrence of symptoms.

CASE 2. Y. P., white, male, aged 52 years, had had symptoms referable to the right leg for 7 years. A typical history was noted. When the patient was first seen he showed evidence of having developed some compensatory collateral circulation. Following a series of treatments, pulsations developed in the posterior tibial artery, and the subjective symptoms disappeared.

CASE 3. M. M., white, male, aged 30 years, had had symptoms referable to the left leg for 3 years. One year previous to the time he was first seen, the second toe had been amputated because of dry gangrene. This amputated stump did not heal. When first seen, examination revealed an unhealed amputation stump of the second toe and a perforating ulcer on the plantar surface of the third toe. Because of excruciating pain and inability to rest, the patient had entered the hospital for amputation. An interesting observation in this case was that he had considerable œdema in the affected foot, but without signs of active infection. Treatment was followed first by almost immediate disappearance of pain, then by gradual reduction of swelling, and, after several weeks, by healing of the ulcers.

OBLITERATIVE ARTERIOSCLEROTIC DISEASE

CASE 1. T. M., white, male, aged 54 years, had had symptoms in the left leg for 3 years due to obliterative arteriosclerotic disease of the left lower extremity with severe degree of secondary anæmia. The latter was treated first. Following improvement, passive vascular exercises were started to which he responded rapidly.

CASE 2. F. C., white, male, aged 51 years, had an obliterative arteriosclerotic disease of the right foot and leg with several large painful ulcerations. There had been no response over a period of 2 years to any form of therapy. Following passive exercise in conjunction with prescribed conservative therapeutic measures there was complete disappearance of symptoms with healing of the ulcerations.

FROSTBITE GANGRENE

Ritter reported favorable results in the treatment of frostbite gangrene with hot air. He suggested that it was due to the exercising and strengthening of apparently paralyzed vessels. He also stated that stasis hyperæmia was also effective, due possibly to stimulation or regeneration of injured cells.

CASE 1. J. F., colored, male, aged 20 years, gave a history of exposure to cold over a period of 8 hours. He was seen about 4 hours after his initial exposure, at which time examination revealed large vesicles on both the dorsal and palmar surfaces of all of the fingers of the right hand. There was a definite line of discoloration at the junction of the distal and middle phalanges. The entire hand was cold, swollen, and indurated. Normal pulsations were obtained in the radial artery. In addition to the pathological condition in the right hand, the little finger of the left hand was swollen and indurated. The patient's right hand was treated at 6 hour intervals over a period of 48 hours. This was continued for 3 weeks, the frequency of treatments being gradually tapered off. At the end of this time there had been complete desquamation of the outer layer of the skin of all the fingers, with loss of the nails. There was no necrosis of the soft tissues. He has been seen at intervals during the past 3 months, and there is no evidence of tissue destruction. All of the finger nails have regenerated. On the left hand which was untreated, and which, by comparison, showed much less evidence of frostbite, necrosis of the distal phalanx of the little finger developed.

CASE 2. H. C., colored, male, aged 34 years, gave a history of exposure to cold over a period of 12 hours, while working on a grain elevator during one of the coldest nights of the year. He was seen within 6 hours of his exposure, at which time examination revealed extensive vesication of all the fingers of both hands. There was a very definite blue black discoloration of the middle and distal ends of the proximal phalanges. In addition both hands were cold, indurated, and considerably swollen. Radial pulsations were apparently normal. He was treated every 6 hours over a period of 72 hours. The frequency of treatments was then gradually decreased. At the end of 2 weeks there had been complete loss of the superficial epithelium over the involved areas, with loss of all the finger nails except the left thumb nail. There was no destruction of soft tissues. He has been seen at frequent intervals over a period of 3 months, and there is no apparent residual change except for loss of pigment.

In addition to these 2 cases 3 other patients were similarly treated with no apparent residual damage except for the loss of pigmentation.

It will be remembered that the past winter was a very cold one and other patients were seen who were not treated by passive vascular

exercise. These ran the usual course of frostbite necrosis and in most instances lost varying lengths of their fingers or toes.

UNUNITED FRACTURES AND DELAYED UNION

Ambroise Paré was the first to use artificial stasis hyperæmia in insufficient callus formation. In 1875 Nicolodoni described Dumreicher's method for treatment of insufficient callus. He stated, "Perhaps we will succeed in reaching our goal if we are able to send a larger quantity of nutritive material to the threatened place. If we can still more fill the vessels, and if the tissues are in a condition fit to take up the material, of which we now have an abundance, an artificially produced and permanently maintained hyperæmia *per se* will exercise a powerful stimulus on the tissues and tissue elements, which participate in formation of callus in accordance with the relation of added nutrition to function." In 1886, Brum cited 5 cases of insufficient callus formation satisfactorily treated by means of artificial hyperæmia.

CASE 1. G. H., white, female, aged 43 years, had a simple comminuted fracture of the left tibia and fibula, middle third, which 4 months after the initial injury showed but slight evidence of callus formation either clinically or by X-ray. General examination was entirely negative except for the local pathology. Pulsation was present in dorsalis pedis and posterior tibial arteries. Wassermann reaction was negative. After 5 weeks of treatment there was sufficient callus formation, which was confirmed by the X-ray, to permit of weight bearing. At the end of 7 weeks the patient was permitted to walk without any type of support. She has been seen since at 2 week intervals. She has firm union and walks normally.

CASE 2. J. S., white, female, aged 32 years, had a fracture of the right radius and ulna at the middle third. An open reduction was performed 6 days after the initial injury. She was observed over a period of 10 weeks from the time of her injury and showed no evidence of callus formation either clinically or by the X-ray. No explanation for the failure of callus formation could be found. She was given a series of passive vascular exercises, and in 3 weeks there had developed clinical evidence of sufficient callus formation to justify removal of the splints. In 5 weeks' time patient showed normal bony union clinically and by the X-ray.

ARTHRITIS

One of the patients with thrombo-angiitis obliterans had been having symptoms referable to his joints over a period of 5 years. A diagnosis of hypertrophic arthritis had been made. When first seen he was complaining of pain and stiffness in the left knee even more bitterly than of the symptoms in the left foot, in which thrombo-angiitis obliterans was present. While placing the rubber collar about his leg and introducing the foot and leg into the boot he complained of severe pain and tenderness in the knee. After being treated twice daily over a period of 3 weeks there was noted a marked subsidence of symptoms in the foot and complete disappearance of symptoms referable to the knee. Whether this improvement was coincidental or due to circulatory improvement will have to be proved. However, another case of hypertrophic arthritis is now under treatment. This patient has shown marked amelioration of symptoms.

Concerning arthritis, Pemberton has made the following observations. "The derangement of function, which physicians are now able to recognize as constituting a background of the rheumatoid problem is one that has to do probably in several ways with disturbance of the finer blood supply to various parts of the body and apparently more or less in both types of arthritis.

"Arthritic persons, as a whole, have lower peripheral temperatures than do normal persons, because of the decreased blood flow in the tissues concerned. The capillary bed is seen to be rather immobile in a state resembling vasoconstriction, and unresponsive to those adaptations which changes in the environment imposed on it."

With these statements of Pemberton's and the observations noted in the 2 cases mentioned, the suggestion is made that possibly we may now have available a simple form of treatment that, in conjunction with accepted forms of therapy, may prove of great value in the treatment of these particular types of arthritis.

Perhaps the most interesting group of cases treated was a small series of 4 patients with disturbances associated with trauma of the forearm. In 2 of these the diagnosis was ischæmic palsy; in the 2 others there were glossy, stiff fingers, with burning pains

involving the forearm and fingers. There had been no direct trauma to the median nerve, unless pressure from tight splints on the lower forearm could produce such an injury. But for the absence of direct median nerve injury, the condition resembled causalgia.

CASE 1. T. G., white, male, aged 46 years. Patient sustained a fracture of the left radius and ulna which, after reduction, was immobilized in a plaster cast. The wrist was placed in the gooseneck position and the elbow was included in the cast. Within 24 hours the patient complained of such severe pain that the upper portion of the cast was removed, thereby freeing the elbow. There was a tremendous amount of œdema in the elbow region, so the remaining portion of the cast was split. The pain and œdema persisted to such a degree that 2 days later the cast was removed. He was hospitalized for a period of 6 days during which time the œdema subsided. However, he complained of increasing pain in the region of the wrist and in the second and third fingers, as well as numbness of all the fingers with loss of extension and flexion. He was seen by us 3 weeks after his initial injury, at which time he was complaining of a severe "boring" type of pain in the region of the wrist and of the second and third fingers, with inability to sleep. Examination showed the affected arm to be smaller than the good one; it was quite cold on palpation. Pulsation in the radial artery was apparently normal. There was a dusky discoloration, with evidence of definite beginning fibrotic changes in the soft tissues of the forearm and in the elbow region. There was loss of pronation and supination, and partial loss of ability to extend and flex the fingers. X-ray examinations showed normal callus formation at the site of the fractures. There was considerable absorption of the carpal bones and of all of the phalanges. Within 48 hours after beginning treatment he had complete relief from pain. Following this relief it was no longer necessary to administer any type of narcotic or analgesia. After being treated for 2 months physiotherapy measures were begun, consisting of manipulation, massage, and faradic current stimulation. He was able to flex and extend his fingers and wrist and had partial recovery of pronation and supination. Seen 4 months after his initial injury he shows very little evidence of any permanent damage.

CASE 2. E. S., white, male, aged 38 years. Patient sustained a massive contusion of the right forearm following which splints were applied. Subsequent X-ray was negative for fracture, and the splints were removed at the end of 24 hours. During this time there had developed such a tremendous amount of œdema of the forearm accompanied by such excruciating pain that hospitalization was necessary. He was seen by us for the first time 4 weeks after injury. At that time he was complaining of severe pain along the radial side of the hand. Examination showed evidence of fibrosis of the tendons of the forearm accompanied by loss of ability of pronation and supination; loss of ability to flex the fingers, and loss of ability to extend the fingers except on flexion of the wrist. The hand felt cold on palpation.

Following a series of treatments he had prompt relief of pain. When evidence of improved circulation was discerned he was given physiotherapy treatments consisting of manipulation and faradic stimulation. After 8 weeks of treatment he has almost complete recovery of pronation and supination. There is also recovery of extension and flexion, except for the index finger which shows only partial recovery. The hand feels warm and the patient no longer complains of discomfort.

The last 2 cases in this report were very similar. Both had very painful arms following fracture without evidence of ischæmic palsy. The pain and burning resembled that seen in causalgia. The fingers were glazed and stiff, any motion was painful, and most of the forearm and hand motions were limited, especially pronation and supination.

One of these patients was a woman 50 years old who had a Colles' fracture in March, 1933, and 4 months later suffered a fracture through the elbow joint. The symptoms mentioned followed the elbow injury. In this patient there was extensive œdema of the dorsal surface of the hand. After treatment was begun there was an early and almost complete disappearance of the burning and pain. There was gradual improvement in the condition of the hand and all motions improved. At the present time there is little disability except weakness which is noticed after the arm has been exercised for some time.

The next patient was a white woman, aged 60 years, who was sent in because there was a faulty reduction of a Colles' fracture, and after removal of the cast there was a great deal of pain and burning in the hand, forearm, and arm. This patient carried the arm in partial elbow flexion and was unwilling to move the entire extremity because of pain. There was muscle and bone atrophy, marked limitation of all motions, and the fingers were stiff, discolored, smooth and painful. She was sent in to have the faulty reduction corrected. It was thought that further trauma would only increase the severity of her discomfort and disability, so that, in spite of the deformity at the wrist, this patient was treated by passive vascular exercise. The result was very prompt and most striking. Pain ceased after a few treatments and the arm and forearm movements rapidly returned. She began to flex and extend her fingers at the end of a week, and after 6 weeks of intensive treatment the only serious residual damage was the deformity due to the unreduced Colles' fracture.

BIBLIOGRAPHY

1. BIER, AUGUST. Hyperemia as a Therapeutic Agent.
2. HUNTER, J. I. Surg., Gynec. & Obst., 1924, xxxix, 721–743.
3. JUNOD referred to by Bier.
4. LANDIS, EUGENE M., and GIBBON, JOHN H. J. Clin. Invest., 1933, xii, 925–961.
5. LERICHE, R. Am. J. Surg., 1931, xiv, 55–67.
6. MORTON, J. J., and SCOTT, W. J. M. New England M. J., 1931, cciv, 955–962.
7. PARÉ referred to by Bier.
8. PEARSE, HERMAN E. J. Am. M. Ass., 1932, xcviii, 866–870.
9. PEMBERTON, RALPH. J. Am. M. Ass., 1931, xcvi, 33. Arthritis and Rheumatoid Conditions. Philadelphia: Lea and Feb'ger, 1929.
10. REID, MONT R. Ann. Surg., 1932, xcvi, 733–743.
11. Idem. Am. J. Surg., 1934, xxiv, 11–35.
12. RITTER referred to by Bier.
13. ROYLE, N.D. Surg., Gynec. & Obst., 1924, xxxix, 701–720.

SURGICAL LIMITATIONS IN THE TREATMENT OF ACUTE SUPPURATIVE PERITONITIS[1]

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THE literature of acute peritonitis, both American and foreign, is greater than that devoted to any other surgical condition, yet the high mortality of acute spreading peritonitis accompanying such lesions as suppurative appendicitis, postoperative contamination and leakage, and peptic perforation, forces the recognition that very extensive experimental and clinical study has suggested no satisfactory operative attack. For approximately 50 years method has succeeded method in the surgery of peritonitis. As we review the various types of treatment that have been applied over this period, it becomes evident that our surgical indications and treatment have not been governed by the pathological physiology of the peritoneum. Thus we know that drainage, with no matter what type of drain, in the presence of unencapsulated and advancing suppuration, results promptly in fistulization; that postural methods, based originally on anatomical misconceptions, do not materially lessen toxæmia or improve prognosis; that lavage and irrigation with irritants, antiseptics, and hypertonic solutions not only fail to limit infection and to lessen spread, but actually accomplish the reverse; that enterostomy seldom effects more than the deflation of a distended loop and does very little for a paralytic ileus, which in turn has little to do with the mechanism of death; that in the presence of actual suppuration, spinal anæsthesia is likewise ineffective in the control of ileus; that fistulizing the thoracic duct merely causes fatal dehydration and does not lessen toxæmia; that the increasing advance of suppuration responds neither to blood transfusion, nor to the restoration of depleted blood chemistry. But it must also be admitted that treatment, based upon an intelligent respect for the physiology of the peritoneum, has made little improvement in the mortality statistics. It is our purpose in this discussion to indicate what appear to be certain basic errors in the clinical appraisal and pathological diagnosis of acute peritonitis in the light of experimental and clinical observation, and to suggest what surgical limitations are imposed in the management of this disease. A résumé of accepted facts on the pathological physiology of this disease will bear repetition.

PATHOLOGICAL PHYSIOLOGY

Two functions of the peritoneum are of major importance: absorption and exudation. Starling and Tubby, Dandy and Rowntree, Clairmont and Haberer, Reschke, Kuhn, Hertzler, and many others have built up this knowledge for us. A consensus of opinion from the experimental standpoint indicates that there is active absorption from all parts of the peritoneum, visceral, parietal, the omentum, the cul-de-sac, and the diaphragm; that the open channels or stomata, described by von Recklinghausen, in 1863, do not exist. Starling and Tubby found that dyes injected intraperitoneally appeared in the blood before they did in the thoracic duct. Dandy

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and Rowntree cannulized the thoracic duct and urinary bladder and showed the chief avenue of absorption of isotonic fluids was the blood vessels; that absorption was equal in all postures, excepting pelvis down, in which position they found absorption increased 15 per cent—a fact for which they could give no explanation. They found phenolsulphonephthalein in the urine 4 minutes after intraperitoneal injection and found that ligation of the thoracic duct did not modify the time of appearance in the urine. It is known that crystalloids are absorbed more rapidly than colloids. This is particularly true of albuminous fluids, of which pus is an example. Albuminous substances and suspensions of particulate matter, while slow in absorption, are also absorbed through the peritoneal lymphatics, which in turn drain into the abdominal lymphatic glands and not into the thoracic duct. Costain, attributing the major rôle of absorption to the lymphatics, suggested lymphaticostomy, but the thoracic duct is primarily a collecting duct for lacteals. Toxic absorption is greater in the normal peritoneum than in the inflamed membrane and the absorption of albuminous fluids is more modified by inflammation than is the absorption of crystalloid solutions. Absorption is increased by peristalsis and, to some extent, by heat, although the latter statement is a debatable point. Under conditions of inflammation, absorption is greater when the exudate is thin in consistency and small in volume. Bulky exudates tax the absorptive capacity of the peritoneum and markedly slow the rate of absorption on the third or fourth day of the disease, as can be demonstrated by intraperitoneal injections of hypertonic dextrose solution in a dog with diffuse peritonitis.

Absorption is diminished by hypertonic solutions, by cold, by such substances as glycerin, olive oil, collodion, adrenalin, and ascitic fluid. It is also diminished by distention and by fibrin. The function of fibrin in slowing absorption explains the subsidence of toxic reaction in the presence of localization. Even crystalloids are slowly absorbed from fibrin-coated peritoneum. This would seem to suggest the association of virulent infection and watery, thin exudates. Experimentally, we (2) noted that the streptococcus usually predominates in such exudates. The rate of absorption is markedly diminished in the later stages of a peritonitis, notably after the third or fourth day.

The typical peritoneal response to inflammation is exudation; normally serous, peritoneal secretion rapidly shows fibrin in the presence of irritation. Yates stated that relative encapsulation of a drain was immediate. In an experimental study we (2) were able to demonstrate fibrin in the presence of a drain within an hour and to prevent its formation under the same conditions for 72 hours by the repeated intraperitoneal injections of hypertonic (20 per cent) dextrose solution. Experimental and clinical observation has shown that the maximum fibrin formation occurs in the presence of moderate degrees of inflammation, and that it may be completely absent in the presence of virulent infection, such as is produced by the streptococcus. We were able to show experimentally that while virulent infections may not evoke fibrin formation, that a foreign body, such as a drain, always will. Cubbins, in an experimental study of the normal peritoneum, showed that no substance, however bland or sterile, could be introduced without evoking fibrin masses; that sterile vaseline was as provocative of adhesions as tincture of iodine.

In an interesting experimental study on the mechanism of death in diffuse peritonitis, Steinberg concludes that death is caused by toxins from bacteria in the peritoneum; that intestinal paralysis, stasis, and bacteria play no part. With the idea of slowing resorption, Kuhn injected 50 per cent dextrose solution intraperitoneally in amounts equal to 1 per cent of the body weight in both dogs and in man. He overlooked the fact that the marked dilution of the inflammatory exudate resulting thereby materially lessened or prevented the formation of fibrin, the most important single factor inhibiting, or at least lessening absorption. In our own experimental work, we found that intraperitoneal injection of hypertonic dextrose solution in dogs suffering from diffuse peritonitis shortened the life expectancy of the animal by 50 per cent. We also

noted that the active absorptive capacity of the peritoneum was maintained, as was shown by the disappearance of sugar from the exudate at autopsy. It was also our observation that hypertonic dextrose solution markedly increased the rate of diffusion of infection.

RELATION OF CLINICAL PICTURE TO PATHOLOGY

That there is frequently a basic error in the clinical appraisal and pathological diagnosis, especially in cases of acute spreading and acute diffuse peritonitis, is evident from a study of clinical reports on cures of so called "general" peritonitis. The clinical signs by which we diagnose an advancing infection of the peritoneum will usually not serve to define its extent. At operation we are rarely justified in attempting to determine the extent of infection by exposing and exploring uninvolved portions of the abdomen. Experimentally, we have found a copious exudate, forced probably by peristalsis, to regions showing no gross inflammatory changes, a fact that has led us to believe that gravity is not a major factor in the extension of the disease. Tenderness in the abdominal wall extends far beyond the actual zone of involvement in spreading peritonitis; this is commonly responsible for error in judging the extent of peritoneal involvement. In a localized process the zone of tenderness extends very little beyond the actual border of peritoneal involvement. Clinically, we have drained an abscess, 3 weeks after perforation of a peptic ulcer, that occupied a large part of the left sagittal half of the peritoneum, so extensive in size as to crowd much of the small bowel through the right half of the abdomen. Two liters of pus was removed from this abscess, yet in spite of extensive involvement, the picture was essentially that of abscess and not of spreading infection.

A differential diagnosis between a localizing and a diffuse process is more readily made than between a diffuse process and a generalized one. The markedly lessened toxic reaction that accompanies fibrin mobilization, the usual absence of ileus and a more sharply demarcated zone of tenderness are differentiating features. Ileus, thready pulse, and vomiting are associated with a diffusing process. Those patients who recover from such a clinical course are often classified as recoveries from general peritonitis. In our opinion, the term "general peritonitis" is a misnomer and in most instances should be restricted to patients who are moribund, or who obviously cannot recover.

DRAINAGE

In considering the problems involved in peritoneal drainage the point that is frequently lost sight of is the difference in the reaction to drains of the diffuse and localized types of infection. Writers far too numerous to quote have shown the inefficacy of drainage in spreading and diffuse peritonitis. It is necessary to emphasize, however, that peritoneal abscess always requires drainage. The reason for this fact lies in the fundamental pathological difference between an abscess and a spreading infection. The peritoneal surfaces that make up an abscess have lost the power of movement, and are covered with fibrin, are œdematous, and more or less inelastic. The capacity for encapsulation has been lost by previous plastic fixation, and proper drainage material not only functions as such, but serves to prevent re-accumulation. We have noted in experimental animals that fibrin does not cling to a drain inserted into an abscess. It may plug the opening or fenestrations in a tube, but the latter will not fistulize unless left in until granulations cover it. This statement holds true, regardless of the size of the abscess, because the functions of exudation and absorption virtually cease in the presence of a well defined deposit of fibrin.

In the light of definite experimental and clinical data discussed here, it should be easy to dispose of the problem of drainage in diffuse peritonitis by stating that this condition should never be subjected to drains. If we are dealing with an unquestioned diffuse process, in which the small bowel and omentum can be observed without undue handling to be mobile, we can definitely omit drainage. But within the limits of some incisions this cannot always be determined with certainty, since encapsulation about a septic focus may precede pus accumulation. We believe that an area of definite encapsulation, even though

there be no purulent accumulation in the encapsulated area, should be regarded as a potential abscess and drained. On the other hand, too frequently unencapsulated accumulations of pus are regarded as local processes and drained. A typical example of such an error is that of a phlegmonous appendix, accompanied by the gravitation of unencapsulated pus into the pelvis; or a spreading infection accompanying such an appendix, in which a copious purulent exudate wells up between loops of freely mobile small bowel. It was for such a condition that surgeons of a generation ago made multiple stab wounds and put rubber tubes or gauze strips into each wound.

In experimental animals we have been impressed not so much by the inefficacy of drains lying between mobile loops of small bowel, as by the actual serious damage resulting therefrom. First of all it is utterly impossible in a patient to determine the patency of a drain. Perhaps gauze is an exception to this statement, because the meshes throughout its contact with peritoneal surfaces always fill with fibrin and granulations, but a drain of rubber tissue, the ideal type for use in contact with the peritoneum, may appear and feel to be free and unencapsulated. The fallacy of such a supposition is shown in the experimental animal, where it can be demonstrated that only partial encapsulation is the rule, but that this encapsulation, even if slight, nullifies the function of the drain. In this connection it is interesting to note that openings and fenestrations in rubber tubes become more quickly adherent and plugged than do the walls of the tube. This is particularly true if the tube should lie in the vicinity of unattached omentum.

It has been our observation at autopsies upon patients who had died from widespread peritonitis, within a few hours to a day or so after a last desperate attempt had been made to save them by hasty incision and drainage, that there was encapsulation of the drain and not about the septic focus. Duplicating such conditions in dogs, we found that, in animals within 6 hours of death, in one instance 2 hours, where no agglutination of loops or omentum had occurred, the drain was sufficiently encapsulated to prevent its functioning as such. We saw this sufficiently often to feel that the peritoneum is at all times more capable of isolating a drain than an inflammatory focus. The more fibrinous the exudate, paradoxical as it may seem, the less likely will there be encapsulation of the drain. The most striking experimental proof of this statement is the prompt encapsulation of a soft rubber drain in a copious watery thin and virtually fibrin free exudate.

Experimentally, the damage most uniformly evoked by drainage is residual abscess. The reason for residual abscess about a drain is that richness of fibrin deposit about a foreign body produces conditions favorable to purulent accumulations. Furthermore, when a drain was inserted in such a way as to cross a zone of spread into unaffected loops, the latter became more rapidly involved by the inflammatory process than any other area. From clinical observation we are inclined to believe that a residual abscess forming as the result of a drain is less likely to disappear spontaneously than such an abscess as forms in the absence of a drain. The gradual absorption of an abscess in an unopened abdomen is an example of the latter condition. It seems likely that pus accumulations, when encapsulated, may remain for a far greater length of time than we suspect. We have found pus in the peritoneum of apparently healthy dogs as long as 100 days.

Exudates that form rapidly are accompanied by rapid toxin absorption. The increased capacity of the peritoneum for absorption in the early stage of the disease has been mentioned. It would seem, therefore, that the removal of such exudate at the time of operation is important. When large accumulations of exudate are present, such as occur in peptic perforation and in diffuse suppuration, following gangrenous or phlegmonous appendicitis, the removal of the major part of the exudate undoubtedly lessens toxic reaction and also lessens the tendency to residual abscess formation.

A large accumulation of exudate will often be found above the liver in peptic perforation and will pour out when the liver is depressed by the hand. In some instances postopera-

We subphrenic abscess can be traced to such an overlooked accumulation. Pelvic abscess, following drainage of diffuse appendiceal peritonitis, has been observed many times, a week or more after the removal of a drain.

SURGICAL LIMITATIONS

It would seem from the foregoing that the operative therapy of spreading peritonitis is limited to the removal or closure of a septic focus, aspiration of the exudate, and closure of the peritoneum without drainage. It is, of course, necessary that the abdominal wound above the serosa be drained. In our experimental peritonitis we (3) produced a so called lethal standard of diffuse peritonitis by means of an open loop of ileum that had a mortality of 90 per cent, with a life expectancy averaging 4 days. When we removed the septic loop at the end of 24 hours, the mortality was reduced to 58 per cent. This was a severe test, because we were dealing with a perforative peritonitis from the terminal ileum. The two closest analogies to this experimental situation are progressive diffuse appendiceal peritonitis and leakage from an intestinal suture line. An appendix is occasionally permitted to "cool off" before operative attack. We believe that only a subsiding abscess should so be left alone and only so long as the abdomen, temperature, and pulse suggest definite localization. At any time during the stage of spread or advance, the appendix, as a source of contamination, should be removed. It has been argued that operation during a spreading peritonitis increases the rate of spread and the area of contamination. Both our experimental and clinical observations are opposed to this opinion.

Postoperative spreading peritonitis, particularly when the source is the intestinal tract, is nearly always a catastrophe, yet there is both justification and indication to invade the operative field early in the event of serious soiling. The obvious difficulty, of course, is that of diagnosis. While all postoperative distention or ileus, accompanied by nausea and vomiting, indicates peritoneal reaction, when a mounting temperature and particularly a rapidly mounting and persistently high pulse are present, we believe it preferable promptly to re-open the abdomen, rather than to wait. It does not require a general peritonitis, or even a widespread lesion, to cause death. It is obvious, therefore, that prompt differentiation between serious soiling with infection and ileus without gross soiling must be made.

Quite in contrast to the line of attack in postoperative diffuse peritonitis, are the indications in postoperative peritoneal abscess. It is seldom advisable to attack the abscess until it is of sufficient size to assure both complete walling off and indications of its location and parietal relationships. Notable exceptions are the subphrenic and pelvic abscesses.

Experimental workers are familiar with the fact that dogs will frequently show no discernible reaction to the intraperitoneal injections of cultures or suspensions of living pathogenic organisms, such as the colon bacillus, staphylococcus, and streptococcus. On the other hand, a freshly localizing infection possesses a particular virulence for the uninvolved peritoneum. The inexperienced and unskilled finger has produced many deaths in such situations, and if there is any one fact that will bear repetition it is that fresh fibrinous adhesions should be regarded as inviolate. The shortest extraperitoneal route must be made the drainage pathway; for example, by making a muscle splitting incision close to the spine of the ileum, a pus distended appendix can be delivered from a walled off abscess without the prolapse of a loop of small bowel, an accident that may spell disaster. Since seldom does small bowel make up the wall of an appendiceal abscess, its presence in the field in such a condition should be regarded as a technical accident. A pelvic gravitation abscess impinging upon the rectum can be drained, with far greater safety, rectally than by pushing the finger along the old drainage tract. A subphrenic abscess to the right of the falciform ligament, as most of them fortunately are, can be drained extraperitoneally by the very satisfactory method suggested by Nather and Ochsner.

Several times we have found that X-ray films offer considerable help in demonstrating residual abscess in atypical locations, such, for instance, as the left subdiaphragmatic

area; between the ascending colon and the abdominal wall; and between the omentum and the anterior abdominal wall. When such abscesses can be so accurately located, direct extraperitoneal attack is simplified.

SUMMARY

We are omitting from consideration, details of non-operative treatment of diffuse peritonitis, such as maintenance of fluid balance, of blood chlorides and sugar, gastro-intestinal decompression with the Levine tube, etc. The latter procedures are, of course, extremely important phases of treatment and, in fact, in many instances represent the only treatment applicable. But we also believe that operative therapy in spreading or diffuse lesions is limited to removal of the source of infection, be it a suppurating appendix or a leaking suture line in bowel. We also believe that early operative attack during the stage of attack is better than so called "conservative management" that aims by immobilization and non-interference to promote localization. Lastly, aspiration of accumulations of exudate is an important factor in diminishing the immediate toxic reaction and in lessening the tendency to residual abscess formation.

CONCLUSIONS

All methods of direct surgical attack upon suppurative spreading peritonitis, based upon alteration of, or interference with, the functions of absorption and exudation, tend to increase the mortality.

Drains function in localized peritoneal abscesses, but in spreading processes, not only encapsulate, regardless of the consistency of the exudate, but also provoke residual abscess and increase the diffusion of the infection.

In the stage of spreading or diffuse peritonitis, removal of a septic focus, such as an appendix, or closure of a postoperative leakage, followed by aspiration of the major portion of the exudate, represents the surgical limitations in the treatment of this disease.

BIBLIOGRAPHY

1. Buchbinder, J. R. Prevention of peritoneal adhesions and encapsulation; a preliminary report of an experimental study of peritoneal reaction to hypertonic dextrose solution. Surg., Gynec. & Obst., 1927, xlv, 769–774.
2. Buchbinder, J. R., Heilman, F. R., and Foster, G. C. Experimental peritonitis. II. The effect of hypertonic dextrose solution upon diffuse peritonitis. Surg., Gynec. & Obst., 1929, xlix, 788–793.
3. Buchbinder, J. R., Droegemueller, W. A., and Heilman, F. R. Experimental peritonitis. III. The effect of drainage upon experimental diffuse peritonitis. Surg., Gynec. & Obst., 1931, liii, 726–729.
4. Clairmont and Haberer. Experimentelle Untersuchungen zur physiologie und Pathologie des Peritoneums. Arch. f. klin. Chir., 1905, lxxvi, 1–36.
5. Costain, W. A. Lymphaticostomy in peritonitis. Surg., Gynec. & Obst., 1923, xxxvi, 365–367.
6. Cubbins, W. R. A preliminary report concerning the effect of foreign substances in the peritoneal cavity. Surg., Gynec. & Obst., 1916, xxii, 571–579.
7. Dandy, W. E., and Rowntree, L. G. Peritoneal and pleural absorption with reference to postural treatment. Ann. Surg., 1914, lix, 587–594.
8. Hertzler, A. E. The Peritoneum. St. Louis: The C. V. Mosby Co., 1910.
9. Kuhn, F. Die biologische Behandlung der Peritonitis. Muenchen. med. Wchnschr., 1911, lviii, 1998–2002; Die biologische Behandlung der diffusen eitrigene Bauchfellentzuendung. Zentralbl. f. Chir., 1926, liii, 1108–1112.
10. Nather, K., and Ochsner, E. W. A. Retroperitoneal operation for sub-phrenic abscess. Surg., Gynec. & Obst., 1923, xxxvi, 665–673.
11. Reschke, K. Versuche ueber die Beeinflussung der peritoneal Resorption durch hypertonishe Losingen zwecks Anwendung. Arch. f. klin. Chir., 1921, cxvi, 466–521.
12. Starling and Tubby. On the paths of absorption from the peritoneal cavity. J. Physiol., 1897, xxii, 192–205.
13. Steinberg, B. Cause of death in acute diffuse peritonitis. Arch. Surg., 1931, xxiii, 145.
14. Von Recklinghausen. Arch. f. path. Anat., 1863, xxvi, 72–86.
15. Yates, John L. An experimental study of the local effect of peritoneal dranage. Surg., Gynec. & Obst., 1905, i, 473.

THE TREATMENT OF CARCINOMA AT THE RECTOSIGMOID JUNCTION BY OBSTRUCTION RESECTION

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MANY variable factors influence to a marked degree the treatment of carcinoma at the rectosigmoid. It is generally accepted that in obstruction of the bowel, which occurs relatively early in cancer at this site, relief of the obstruction should precede any operative attack on the lesion. The general condition of the patient, particularly cardiovascular efficiency, obesity, the length of the mesentery of the sigmoid, the involvement of the lymphatics by carcinoma, the size of the tumor, other pelvic pathology, as pelvic adhesions from diverticulitis, and the individual preference of the surgeon for one type of operation or another, all lead to varying technical procedures.

The aim of all radical operations for cancer obviously demands not only the adequate removal of the growth, but also the regional lymphatics which drain the involved region. The lymphatics of the rectosigmoid drain into intermediate nodes in the mesentery, but also directly as well as indirectly to the nodes along the inferior mesenteric artery which in turn drain into the lumbar nodes along the aorta. In general, the lymphatic drainage is upward. Villemin, Huard, and Montague after a study of the lymphatics of this region by the injection method of Gerota, believe, that the portion of the rectum above the third valve of Huston is essentially upward. The involvement of lymphatics by pathological processes, however, may not entirely correspond to the findings obtained by injection methods and therefore the communication of the lymphatics from the rectosigmoid with those of the upper rectum is possible and most surgical procedures have been based on the necessity of resecting the entire rectum with its lymphatics when the rectosigmoid is involved in carcinoma. This procedure is sound and radical and implies the division of the inferior mesenteric artery below the first sigmoid branch, with a removal of all of the lymphatics along that artery as well as the lymph nodes in the mesentery of the rectosigmoid and rectum. A permanent end colostomy is necessary. Of these operations the one stage abdominal perineal operation championed especially by Miles, Schmieden, and Jones, is the most radical and answers all of the indications. The only objections are due to the contra-indications for its use in very fat patients or in those whose general condition would not justify the risk. This factor is somewhat personal, depending largely on the experience of the surgeon and his judgment as to what risk he can reasonably take.

For those patients not suited for various reasons to the one stage procedure, a number of variations of the two stage abdominal perineal procedure have been suggested. The operation suggested by Daniel Jones has much to recommend it (Fig. 1). At the first stage the lower sigmoid, rectosigmoid, and rectum are freely mobilized by division of the peritoneum on the lateral and medial sides and between the rectum and bladder. The rectum is separated from the bladder and hollow of the sacrum down to the sacrococcygeal junction. This posterior dissection is behind the superior hæmorrhoidal vessels which are not divided. The inferior mesenteric artery is divided high up below the first sigmoid branch which allows the circulation of the bowel to be carried on through the anastomotic loops between the sigmoid and hæmorrhoidal arteries. Flaps of peritoneum from the cul-de-sac and broad ligaments are formed and the tumor is extraperitonealized. A loop colostomy is made in the midline incision or through a separate incision. At the second stage the bowel is removed extraperitoneally from below. The advantage of this operation is its radicability without the necessity of opening the bowel at the first operation. The disadvantage would be the possible insufficiency of collateral circulation with death of some part of the bowel and consequent infection.

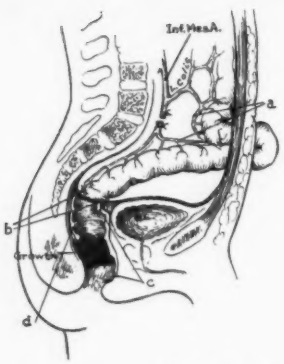

Fig. 1. Jones two stage procedure. At first stage, mobilization above. Ligation of inferior mesenteric artery below first sigmoid branch. Extraperitonealization of growth. Mobilization of pelvic peritoneum and suture of it well above growth. At second stage, removal of rectum from below. (Courtesy Dr. Frank H. Lahey, *Surg., Gynec. & Obst.*, November, 1930.)

Other multiple stage operations have been proposed where the bowel is divided at the first operation. After mobilization of the bowel, Coffey ligates and divides the inferior mesenteric, divides the bowel above the growth, and telescopes the closed end of the distal segment through the tumor until it may be pulled out of the anus. An end colostomy is made with the proximal end of the divided bowel. The distal segment containing the tumor is extraperitonealized by suture of the peritoneum of the cul-de-sac so that a tube may be placed extraperitoneally through the lower end of the abdominal incision to the lower segment of bowel. The disadvantages of this operation are the inability to telescope the distal end of the bowel through the narrowed lumen of the bowel at the site of the tumor and the serious danger of pelvic cellulitis from death of the lower segment before the second stage of the operation is performed from below.

Another two stage procedure has been proposed by Rankin (Fig. 2). He divides the sigmoid above the growth, closes the distal end of the bowel and drops it back without dividing the blood supply to the bowel. The proximal end is used for an end colostomy. At the second stage, the rectum is freed from below, is surrounded by a sterile glove, and then the abdominal portion of the operation is carried out with freeing and removal of the abdominal portion of the bowel and reformation of the pelvic peritoneal floor. The advantage of not opening the bowel at the second stage is obvious, but the magnitude of the second operation is still great. Some risk also exists of leakage from the closed distal loop dropped back into the peritoneum. I have lost a patient from such leakage.

In 1930, Lahey proposed another procedure, based on the division of the bowel and mesentery above the tumor after its free mobilization but without division of the inferior mesenteric and hæmorrhoidal arteries. The end of the distal loop is brought out through the lower end of the abdominal incision and the clamp closing the bowel subsequently released so that between stages the lower segment containing the tumor can be irrigated and cleansed (Fig. 3). The proximal cut end of the bowel is brought out through a left muscle splitting incision for a permanent colostomy. At the second stage the open end of the distal stump is mobilized and closed; a laparotomy is performed and an abdominoperineal resection is carried out. The advantages are the wait between the first and second stages with proper preparation of the distal loop by irrigation and the lack of danger of infection of the peritoneum. The operation is hard to do in fat people with a short mesorectum and has the disadvantage of a difficult second stage operation.

I should like to propose and describe another operation for carcinoma at the rectosigmoid less radical and therefore suitable for use in a limited number of patients but having the advantage of removal of the growth and adjacent lymphatics with final restoration of continuity of the bowel. This operation is applicable to certain cases where the growth is small and where after dividing the lateral and medial peritoneal layers and coming on to the vessels and lymphatics in the mesentery, no lymphatic glands are palpated along the inferior mesenteric artery, and if any are felt in the mesentery of the bowel, they are adjacent to the growth itself. This situation, as far as growth and glandular involvement are concerned, may occur in a patient who is in

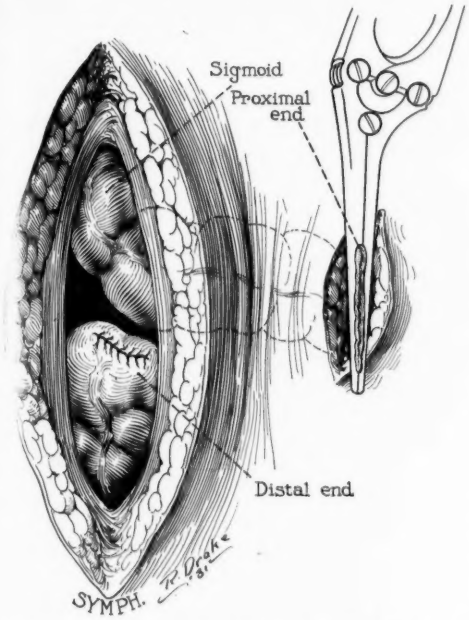

Fig. 2. Rankin two stage resection of rectosigmoid. At first stage the sigmoid is divided above the growth, the distal end closed and dropped back into the peritoneum without dividing the blood supply. (Courtesy Dr. Fred W. Rankin, *Surg., Gynec. & Obst.*, November, 1931.)

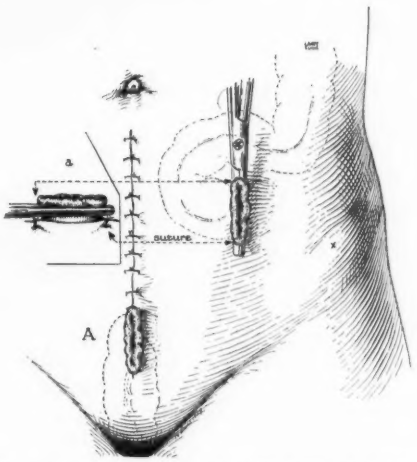

Fig. 3. Lahey two stage resection of rectosigmoid. At first stage the bowel and its mesentery are divided above the growth. The proximal end of the bowel is used for an end colostomy. The cut distal end of the bowel is brought out through the lower end of the abdominal incision. (Courtesy Dr. Frank H. Lahey, *Surg., Gynec. & Obst.*, November, 1930.)

no fit general condition to have an abdominoperineal operation in stages, or may be in a patient who flatly refuses to have a permanent colostomy. There are also a limited number of cases in which it is not certain whether the lesion at the rectosigmoid is benign or malignant. It is therefore under this unusual set of conditions that the operation to be described, is indicated. Not only are the indications for the operation limited for reasons just enumerated but also on anatomical grounds, and it is my feeling, before a definite type of operation is decided upon, that the local pathology and anatomical relations must be carefully determined.

Assuming that in Trendelenburg position a midline or left pararectus incision has been made and the lesion disclosed at the rectosigmoid: the left leaf of the mesentery of the sigmoid and rectum is opened and the incision carried forward at the lower end of the cul-de-sac between the bladder and rectum to join another incision through the peritoneum on the medial surface of the mesosigmoid and mesorectum (Fig. 4, a). The bowel is now pulled toward the median line, marked by mobilizing the bowel at this site, and the medial incision in the mesosigmoid and mesorectum is opened by blunt dissection so that the vessels and lymphatics come plainly into view. If there is no suspicious involvement of the glands along the inferior mesenteric artery and the liver is free from metastases, a further effort may be made to determine whether resection is feasible with eventual establishment of continuity of the bowel. The rectum is next freed from the bladder and its lateral attachments by blunt dissection. The hand is then slipped beneath the bowel behind the superior hæmorrhoidal vessels and the rectum carefully freed from the hollow of the sacrum. After these maneuvers have been carried out it is now possible in suitable cases to lift the bowel containing the growth well out of the pelvis for about 3 to 4 inches higher than its former position, and in so doing, it will be seen that the bowel will be devoid of peritoneum in the depth of the cul-de-sac for a distance of 3 to 4 inches in length. If we

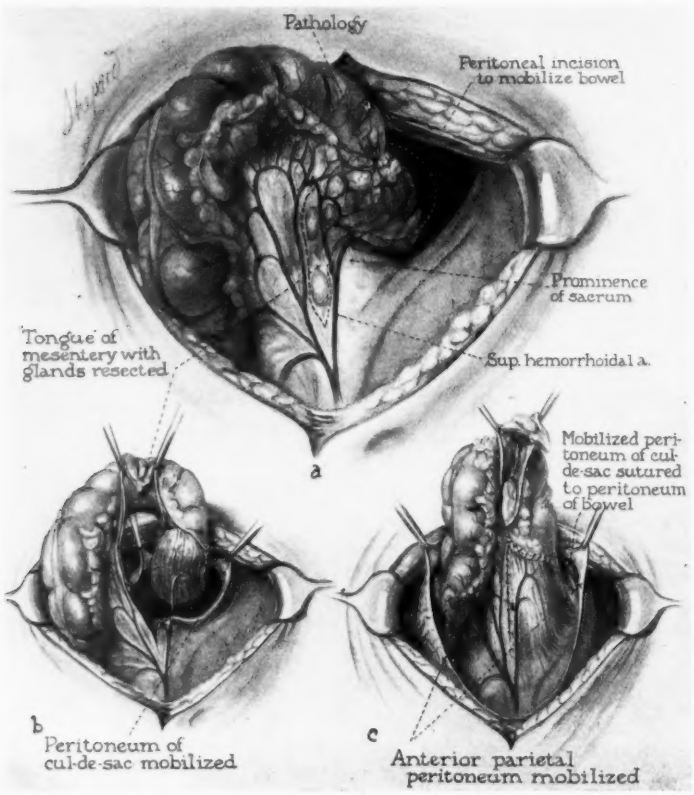

Fig. 4. Proposed resection of rectosigmoid. a, Sigmoid and rectum mobilized but cutting lateral and median peritoneal attachment of bowel. b, Triangle of mesentery of rectosigmoid lifted up with bowel. Rectum freed from hollow of sacrum, bladder, and prostate. Superior hæmorrhoidal artery not divided. Pelvic peritoneum freely mobilized. c, Rectosigmoid now can be lifted out of abdomen. Mobilized peritoneum of cul-de-sac and pelvis elevated and sutured to bowel. Effect is to eliminate cul-de-sac. Anterior parietal peritoneum mobilized.

proceed with the operation in mind it will be necessary (1) to remove the growth with the mesorectum and arteries in the arcade supplying it, down to, but not including, the inferior mesenteric and superior hæmorrhoidal arteries (Fig. 4, b), (2) to have left 2 to 3 inches of peritonealized bowel beneath the proposed site of resection, (3) to cover the denuded deperitonealized bowel in the depth of the cul-de-sac (Fig. 4, c), and (4) to have a large enough sigmoid loop to swing around and sew to the peritoneum covered rectum for a future anastomosis between the two portions of bowel. If any of these postulates are not feasible of performance, the procedure under discussion should be abandoned. If conditions are favorable it is very easy to raise the peritoneum on either side of the cul-de-sac and sew it to a higher level on to the peritoneum of the rectum (Fig. 4, c). This practically obliterates the cul-de-sac and peritonealizes that portion of the bowel which has been drawn upward into the abdomen from below the cul-de-sac. The mesentery of the bowel about to be resected is divided in the usual way, the apex of the resection being slightly above the promontory of the sacrum. A site of resection on the

sigmoid loop is then selected and the area just proximal to this is swung medially so that it comes in contact with the rectum at a point below the site of proposed division of the rectum. The sigmoid and rectum are now tacked together for 1 to 2 inches by interrupted stitches along the longitudinal muscle bundle. *The next step is important because it takes* the point of division of the bowel extraperitoneal. The anterior parietal peritoneum of the abdominal incision is separated from the muscles by blunt dissection so that on both sides of the abdominal incision the peritoneum falls without tension to the posterior parietal peritoneum on both sides of the bowel (Fig. 5, c). At this area the cul-de-sac is practically obliterated by suture of the anterior parietal peritoneum to the posterior parietal peritoneum and the proposed site of resection of the two loops of bowel is therefore extraperitoneal (Fig. 5). At this point the remainder of the operation is carried out by obstructive resection as described by Rankin. Payr clamps are placed on the bowel below the growth and on the sigmoid above it, both clamps being just proximal to the suture of the rectum and sigmoid previously carried out.

The abdominal wall is closed in layers below the clamps around the bowel and the tumor containing the bowel is removed by cautery above the Payr clamps. Strips of iodoform gauze are carefully tucked in between the bowel and the abdominal wall to create enough tissue reaction to prevent spreading infection when the clamps are removed. Varying Rankin's technique, we remove the clamps the next day and immediately apply a spur crushing clamp to enlarge materially the opening between the afferent and efferent loops of bowel. It is this particular step of the operation that in our opinion makes this operation much more useful in its final result than an end-to-end anastomosis of the bowel which at this area is difficult to do and which is very apt to break down. This means infection, scar tissue, retraction of the rectal and sigmoid loops, and resulting narrow lumen at the attempted site of anastomosis. After application of the spur crushing clamp

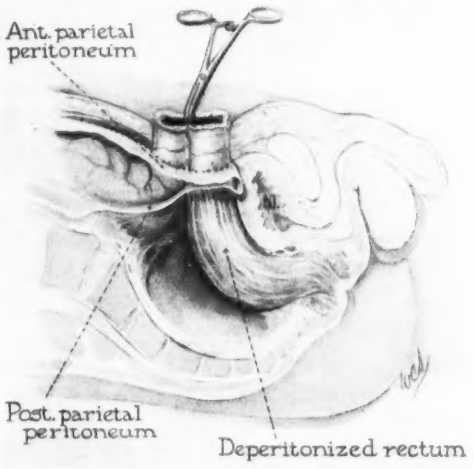

Fig. 5. Lateral view showing afferent and efferent loops of bowel brought together after removal of the tumor. Peritoneum of cul-de-sac elevated to meet mobilized anterior parietal peritoneum, making point of resection of the bowel extraperitoneal. Spur crushing clamp in place. At a later date bowel continuity is re-established.

nothing is done to re-establish continuity for 3 months. If bowel continuity has not been accomplished in that time a second operation under local anæsthesia is done, the ends of the bowel mobilized where they are not in union, and a three layer suture carried out.

We have performed this operation only eight times in 10 years but in those cases in which it has been done we have had no operative deaths and no local recurrence, and one 75 year old patient is alive and well 9½ years from the time of her operation; 1 patient is well 5 years; 1 patient 3½ years. Three are dead of general metastases in liver and lungs, and the 2 others are alive and without recurrence but the operations were done in the past 2 years.

It is, of course, open to question whether any operation for cancer should optionally be done that in any way varies from the utmost radicability. Personally I believe that there are instances in carcinoma of the rectosigmoid in which this type of less radical procedure is indicated, always keeping in mind that the end-results of any operation for cancer speak with the greatest authority.

I. SIMULTANEOUS VEIN LIGATION

An Experimental Study of the Effect of Ligation of the Concomitant Vein on the Incidence of Gangrene Following Arterial Obstruction[1]

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ALTHOUGH the opinion generally prevails that purposeful occlusion of a healthy vein by ligature is a useful method for the prevention of gangrene due to the obstruction of large arteries, some investigators have expressed a doubt as to the value of this procedure. Also, surgeons are prone to employ the method as a routine procedure rather than to use it for a particular set of conditions not frequently encountered. The fundamental problem, therefore, in determining the therapeutic value of the "simultaneous ligation of a vein" is: first, to determine whether this procedure will under any conditions influence favorably the incidence of gangrene after arterial occlusion; and, second, to determine, if possible, the exact conditions which constitute the indication for its employment.

The conditions attending the employment of "simultaneous ligature" of veins in clinical surgery are so complex and are so infrequently observed by one individual, that the effects due solely to this procedure are difficult to determine. Fortunately, however, the problems associated with this procedure would seem to be particularly suitable for solution by animal experimentation. Experimental evidence thus far submitted is conflicting. It is the purpose of this paper to deal only with the results obtained from experimental studies.

The first significant experimental study of the effect of simultaneous ligation of veins on the incidence of gangrene following arterial occlusion was that of Brooks and Martin (1). In this experimental study 3 phases of the problem were particularly investigated.

1. Using the temperature of the tissues as a criterion of volume flow of blood through the tissues, we found that ligation of the concomitant vein produces a further decrease in blood flow than that which had followed obstruction of the artery.

2. Ligation of the concomitant vein caused an increase in the intravascular pressure in all the vessels in which the pressure had been previously diminished by ligature of the artery.

3. Ligation of the right common and right external iliac artery in 21 rabbits was followed by gangrene of the extremity in 15 instances (71.5 per cent). The same ligation of arteries with ligation of the right common iliac vein in 18 rabbits was followed by gangrene of the extremity in 6 instances (33.3 per cent).

Since the publication of this experimental study by Brooks and Martin, the effects of simultaneous ligation of the veins upon the blood pressure and blood flow in the vessels distal to the point of ligation have been confirmed by Pearse, Montgomery, and Wilson. Holman and Edwards confirmed the results obtained by Brooks and Martin as concerning the effect of simultaneous ligation of the vein on blood pressure, but believed the volume flow of blood was increased. The method employed by Holman has been criticized by Brooks (2), Mulvihill, Harvey and Doroszka, and Wilson, and these investigators have shown that the results obtained by Holman and Edwards were evidence for diminution rather than augmentation of the volume flow of blood.

The experiments described by Brooks and Martin in which the effect of simultaneous ligation of the concomitant vein on the incidence of gangrene was determined have recently been repeated by Wilson, whose results are contrary to those obtained by Brooks and Martin. Wilson performed a larger number of experiments than Brooks and Martin and found that the incidence of gangrene was not changed by simultaneous ligation of the concomitant vein. This publication of Wilson's has brought about an extraordinary clarification of the entire question of the effectiveness

[1]From the Department of Surgery, Vanderbilt University

TABLE I

	A Arteries alone ligated	B Arteries and vein ligated
	Number	Number
Total number of experiments	100	100
	Per cent	Per cent
Slight muscle or temperature changes	33	56
Complete paralysis	66	44
Local gangrene	17	2
Massive gangrene	29	2
Late ulceration	7	6
Contracture	15	4

the procedure designated as "simultaneous ligation of the vein" because it, so to speak, puts the question back to the beginning by changing the problem from one of how an effect is produced to whether the effect is produced.

It is worth while calling attention to an inconsistency which exists in Wilson's publication between the statement that simultaneous ligation of veins influences the amount of diminution in volume flow and may influence intravascular pressure after arterial obstruction, and the assertion that this same simultaneous ligation of veins does not influence the incidence of gangrene, nor the severity nor the distribution of muscle necrosis after arterial occlusion. I believe it would be universally admitted that diminution in the volume flow of blood and a decrease in the intravascular pressure are the primordial effects of arterial obstruction, and that these effects are, so to speak, the sole and proximate cause of the necrosis which follows. From this it would seem as if the conclusion were inevitable that any effective influence which were brought to bear upon the quantity of change in either the volume flow of blood or the intravascular pressure must influence in one way or another the incidence of gangrene, unless it were assumed that there was always an exact balance of the favorable influence of the change in one and the unfavorable influence of an obligate change in the other.

The purpose of this paper is to report the results obtained from a more frequent repetition of the experiments originally described by Brooks and Martin.

Rabbits were used as the experimental animals. An attempt was made to repeat in each experiment as nearly as possible the same operative procedure. The abdomen was opened in the midline. The terminal aorta was located. The division of the common iliac artery was identified. The external iliac artery was exposed and ligated just distal to the origin of the hypogastric artery. Exposure of this vessel also exposed the common iliac vein. In the experiments in which the vein was ligated the ligature was applied to the vein at this time. Ligature was then applied to the common iliac artery just proximal to the origin of the hypogastric artery. Thus in each experiment with or without ligation of the vein, the same operative exposure was used. Fine silk thread was used in all experiments for the ligatures. Sufficient care was used to feel confident that the artery or vein was always occluded. (Note this method of ligature is the same as in the experiments of Brooks and Martin but different from that of Wilson, who employed 2 ligatures with division of the artery between.) The sites of the ligatures are shown in Figure 1.

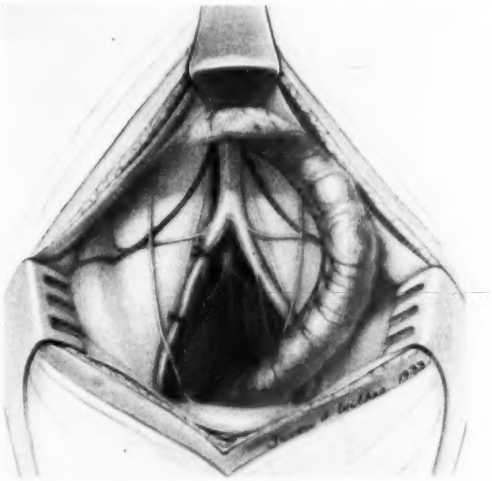

Fig. 1. Drawing illustrating sites of application of ligatures to artery and vein.

After operation the animals were carefully observed each day until death, or the development of obvious gangrene, or until a period of 10 days had elapsed. All the animals which lived longer than 10 days were observed

Fig. 2. Roentgenogram of arteries injected with barium sulphate 5 days after ligation of right common and external iliac arteries and common iliac vein. The animal showed complete paralysis of the right extremity. Note obliteration of the artery at the site of ligation and injection of the arterial tree distal to point of ligation through collateral circulatory bed. (Compare with Fig. 3.)

twice each week in order to determine the nature and extent of the "late" effects of arterial obstruction such as ulceration or contractures. All animals were carefully examined at autopsy.

In 107 experiments the arteries alone were ligated. Both the artery and vein were ligated in 113 experiments. The results obtained showed a striking difference in the incidence of gangrene which followed ligation of the artery alone and that occurring after the ligation of both artery and vein. In each series of experiments there were at least a considerable number of animals which died too soon after operation for the development of the unmistakable evidence of gangrene. But each series contains 100 instances of observations on animals which lived long enough for there to be no doubt about the presence or absence of gangrene. A summary of the results obtained in only those experiments in which it seemed there was no doubt about the presence or absence of gangrene is shown in Table I. This table shows that ligation of the common and external iliac arteries in 100 rabbits was followed by necrosis of a sufficient amount of tissue to be apparent on gross examination in 46 instances, and that ligation of the common and external iliac arteries with simultaneous ligation of the common iliac vein in 100 rabbits was followed by evidence of necrosis on gross examination in 4 instances. It is also worth while to call attention to the relationship existing between the incidence of the various degrees of gangrene observed in the two series of experiments. Massive gangrene of almost the entire extremity was 14.5 times more frequent after ligation of the artery alone, while gangrene limited to portions of the extremity was only 8.5 times more frequent. Necrosis of the skin leading to late ulceration occurred in about the same frequency, with or without ligation of the vein, which is in agreement with the idea previously expressed by Brooks that changes observed relatively late after sudden arterial occlusion were not a part of the problem concerning the effects of simultaneous ligation of the vein in the incidence of gangrene.

As has already been stated, an attempt was made to have the same conditions concerning arterial obstruction present in each series of experiments. A study, however, of the configuration of the arterial tree as indicated by injection of an opaque substance showed the impossibility of attaining this desired end. In 30 of the experimental animals the arterial tree was filled with an injection mass opaque to the roentgen ray. From an examination of the configuration of the arterial tree it was

obvious that there was often a difference in size and origin of branches of the common iliac arteries, but this demonstration is, after all, no more than an illustration of a fact already known, because the very fact that all animals with arteries alone ligated did not develop the same results could hardly be explained in any other manner than by the assumption that there were variations in the amount of obstruction to the blood flow.

A comparison of the roentgenograms of the injected extremities with the physiological changes observed also served to emphasize the fact that the adequacy of the circulation of an extremity cannot always be estimated by the results obtained from the injection of its arteries. Figures 3 and 4 show the roentgenograms of 2 rabbits killed 5 days after the common and external iliac arteries and the common iliac vein had been ligated. There was almost complete paralysis of the entire extremity of the rabbit in which it was possible to inject the artery distal to the obstruction through the collateral circulation, and very little evidence of diminished blood flow in the animal in which none of the injected mass passed through the collateral circulation. Both injections and direct examination of the arteries showed complete occlusion at the site of ligature. Neither animal showed any evidence of necrosis.

The occurrence of contractures after ligation of arteries and of arteries and veins was observed in these experiments. This particular effect of arterial occlusion has been previously investigated by Brooks, who studied the effects of temporary and permanent obstruction of arteries and veins on necrosis and fibrosis of muscle. Brooks differentiated the pathogenesis of contractures following arterial obstruction from those following venous obstruction. He showed that the former develop later, and are not attended by such a degree of severity of inflammation as is associated with the contractures attributable to venous obstruction. In the experiments which constitute the basis of the present paper, contractures developed in 15 animals in which the arteries alone were ligated, and in only 4 instances in which both arteries and veins were ligated. This difference in incidence of contractures becomes more striking if only the animals which lived for 5 or more days are considered. In the series of experiments in which the arteries alone were ligated, only 58 animals lived 5 or more days, while 70 animals with both arteries and veins ligated lived for more than 5 days.

Fig. 3. Roentgenogram of arteries injected with barium sulphate 5 days after ligation of right common and external iliac arteries and common iliac vein. The animal showed only slight evidence of muscle weakness. Note obliteration of the artery at the site of ligation, but little injection of the arterial tree distal to the ligature through collateral circulatory bed. (Compare with Fig. 2.)

Contractures due to growth of connective tissue and scar formation have an entirely

different relationship to a serious impairment of the circulation than gangrene or ulceration. Gangrene, necrosis, and ulceration are the immediate and direct effects of deficient blood flow. Proliferation of connective tissue, scar formation and contracture belong to the process of repair. Contractures after arterial obstruction are, therefore, evidence of a previous impairment of circulation sufficiently great to produce necrosis in tissues more vulnerable than connective tissue. The fact that contractures are less frequently observed after arterial obstruction and simultaneous venous obstruction than after arterial obstruction alone, indicates that simultaneous occlusion of the vein aids in the preservation of the vitality of the more vulnerable tissues during the critical period before the re-establishment of circulation through the collateral vessels.

The results obtained in these experiments indicate that simultaneous ligation of the concomitant vein influences favorably the incidence of gangrene after ligation of the common and external iliac arteries in rabbits. Because of the impossibility of obtaining the same degree of arterial obstruction in successive experiments, this conclusion rests solely upon statistical evidence. A final conclusion can be reached only after the accumulation of a large number of experiments performed by independent investigators.

BIBLIOGRAPHY

1. Brooks, B., and Martin, K. A. J. Am. M. Ass., 1923, lxxx, 1678.
2. Idem. Arch. Surg., 1929, xix, 1.
3. Holman, E., and Edwards, N. E. J. Am. M. Ass., 1927, lxxxviii, 909.
4. Montgomery, M. L. Proc. Soc. Exper. Biol. & Med., 1929, xxvii, 178.
5. Mulvihill, Harvey, and Doroszka. Am. J. Surg., 1931, xiii, 431.
6. Pearse, H. E. Ann. Surg., 1927, lxxxvi, 850.
7. Wilson, W. C. Brit. J. Surg., 1933, xx, No. 79, 393.

STUDIES ON ENDOBRONCHIAL OCCLUSION

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THE chief reason for experimental attempts to create bronchial occlusion is largely the hope that it will be of benefit in the treatment of pulmonary tuberculosis. Many academic and subsidiary stimuli play a part in the attempts to produce this, and those who have attempted to reproduce certain postoperative pulmonary complications, notably massive collapse, have struggled with the matter. The major reasons for this undertaking may be listed as follows:

1. There are to be found in the literature many reports of patients suffering from pulmonary tuberculosis in which atelectasis of the diseased lobe occurred. This atelectasis was due in some cases to the disease itself occluding the bronchus, or the atelectasis was brought about through another mechanism. Recently Jacobaeus, Packard, Gatterdam, Korol, and others have pointed out that the so called fibrotic lung seen in pulmonary tuberculosis is really an atelectatic lung due to bronchial obstruction, and that the disease in this fibrotic lung is usually a benign process. Other cases in which atelectasis has occurred in association with pulmonary tuberculosis with benefit to the patient are found in the reports by Eloesser, Stoloff, and Farris.

2. For the last 10 years interest in the physiology and surgery of the lung has been unusually active, partly because the physiologist has turned to the lung in the study of the circulation, and partly because experiments have been designed to reproduce certain postoperative pulmonary complications, chiefly massive collapse (atelectasis) and abscess. This interest has led to much ingenious investigation, resulting in important additions to our knowledge of pulmonary physiology and pathology. Chief among these accessions is our present conception of atelectasis as a disorder due to bronchial occlusion.

3. We have also the academic logic that, in tuberculosis, rest and approximation of the walls of cavities are the maximum desiderata in therapy (8). It would appear that atelectasis of the diseased lobe might accomplish this far more easily than would the major surgical procedure of extrapleural thoracoplastic collapse operations. Also the bacteriological studies of Novy and Soule have demonstrated that the tubercle bacillus is a strict aerobe and does not survive well under anoxæmic conditions. This suggests that any means which prevents air from approaching the active tuberculous focus is desirable.

4. Finally, there is in favor of a selective collapse of the lung the fundamental consideration that fibrosis is stimulated by anærobic conditions. Coryllos (9) has pointed out that this condition in the lung would be favored by atelectasis. The extreme fibrosis noted by Schlaepfer following ligation of the major branches of the pulmonary artery is in line with this thought.

The attempts to create stenosis experimentally by the endobronchial route began with the investigations of W. E. Adams and Chester M. Van Allen, in 1930, by the study of bronchial injury and repair. They reported the effect of applying to the bronchial mucosa a silver nitrate stick and hot cautery. In their study of the repair processes following this, they noted that several animals survived with complete occlusion. In 1931, Adams and Livingstone (2, 3,) published further experimental work on obstructive pulmonary atelectasis and persistent bronchial fistulæ in which the bronchi were completely occluded by applying 50 per cent and 35 per cent silver nitrate solution to the bronchial mucosa. They were able to produce bronchial occlusion by a single application of the above solutions. This bronchial occlusion resulted in pulmonary atelectasis in all cases in which the occlusion was complete and in which all the bronchi to the lobe were occluded. The bronchial fistulæ closed. These studies were elaborated upon and supported by further reports published in 1932 (4). In this latter

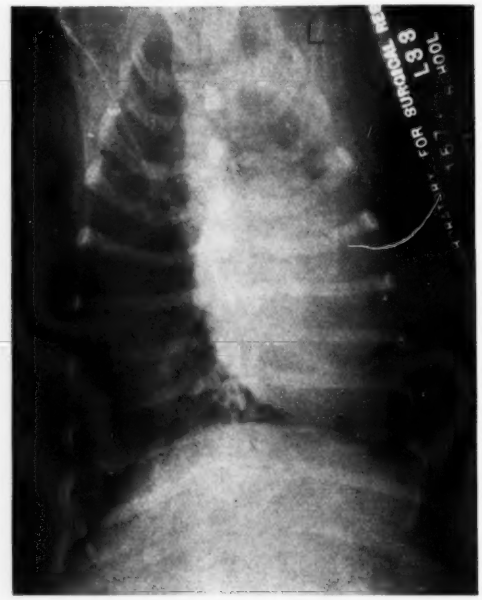

Fig. 1. Animal No. 157-33. X-ray of the chest following three bronchial treatments with acid acriflavine solution. At autopsy the entire left lung was atelectatic. This film shows the heart displaced against the left chest wall, the left diaphragm high, and the left apex cloudy.

article, stronger concentrations were used and a 75 per cent silver nitrate solution was shown to cause sloughing of the bronchial wall. Where atelectasis occurred, it was found that the fibroblastic proliferation was very pronounced. Finally, in 1932, these same investigators applied their ability to produce occlusion by this method to the operation of lobectomy (5). By producing a preliminary bronchial occlusion through the application of silver nitrate solutions they reported greater ease and safety with the procedure.

Other investigators have repeated the work cited without being able to support entirely their contentions, for the mortality rate in other hands has been high, and occlusion has resulted only infrequently. Blalock, using 35 per cent silver nitrate solution, lost 15 out of his first 20 animals and complete stenosis was an infrequent result. Recently Dr. Van Allen told us personally that he, himself, was unable to duplicate the results published by his associate, Dr. Adams. In the surgical laboratories in Cleveland, Dr. Robert Zollinger repeated the work in the winter of 1931–1932 without more success than Blalock. Positive occlusion was so rare, or the mortality so high, that little hope for clinical application could be seen. Other caustics were utilized without greater success.

Beginning in the fall of 1932, we recommenced a study of this problem because of the great clinical value such a method would have were it safe and certain. We began by repeating the experiments of Adams and Livingstone, following their technique as closely as their publications permitted. A pledget of cotton moistened with 35 per cent of silver nitrate solution held in the tip of a bronchial applicator was pressed against the mucous membrane of a bronchus at selected points. Both dogs and monkeys were used. They were anæsthetized before each procedure by the intraperitoneal injection of sodium pentobarbital.

In a series of 20 dogs, one application of the 35 per cent silver nitrate solution failed to produce complete occlusion. Repeated applications yielded only three instances of occlusion with atelectasis. In the same series a marked pneumonitis or hæmorrhagic infarct formation occurred in the lung distal to the application, and destruction of the bronchus so great as to result in fatal hæmorrhage occurred six times. In one experiment a large giant Macacus Rhesus monkey was bronchoscoped repeatedly over a course of 4 months, and a 35 per cent solution of silver nitrate was applied to the bronchus of the right accessory lobe five times during this period. At the end of 5 months this bronchus was constricted to about one-half or one-third of its original diameter, but there was no atelectasis distal to the constriction.

In a second series of animals, a modified Carnoy's[1] solution was used, carrying out experiments similar to those of Dr. Zollinger in 1931. This caustic fluid, developed by Zollinger and Moritz in an attempt to secure the optimum fixation in intracranial cysts

[1] This solution is made as follows:

Absolute alcohol	6 cubic centimeters
Chloroform	3 cubic centimeters
Glacial acetic acid	1 cubic centimeter
Ferric chloride	1 gram

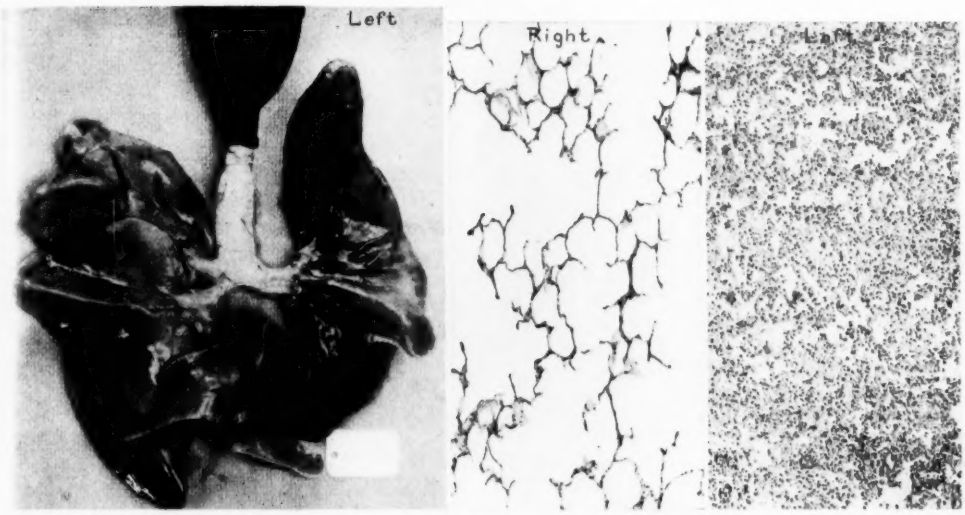

Fig. 2. Animal No. 157-33. Photograph of gross specimen and photomicrographs of sections removed from right and left lungs. The atelectatic left lung appears larger than its true size, for it was stretched upon the background when photographed. When the trachea and right lung were distended with air, the left lung was atelectatic and airless. The roentgenogram of the chest in this case is shown in Figure 1.

without deep penetration, has also been used to produce obliteration of cervical fistulæ and pilonidal sinuses (10). It has properties of moderate penetration with rapid local fixation of cells. Rather marked local fibroblastic reaction occurs in the tissues after its application. This solution was used intrabronchially in 5 animals, the same technique being utilized. It produced a rapid necrosis of the epithelium and bronchial cartilages, with a subsequent fibrosis which in 2 cases resulted in bronchial occlusion and atelectasis. But occlusion occurred without regularity and there occurred three instances of pulmonary hæmorrhage and pulmonary gangrene and abscess formation. This experience, which was similar to that of previous investigations by Zollinger with the same fluid, convinced us that this solution was too caustic in its action, and without a sufficient margin of safety to warrant further work with it.

The next attempt was a return to the earliest experiments of Van Allen and Adams (1). These investigators reported that the cicatrix resulting from the application of actual cautery to the bronchial membrane caused occlusion. In these experiments the surrounding blood vessel wall and lung showed much less reaction following cauterization with heat than following cauterization with silver nitrate. An insulated metal rod, the end of which was capped by a small uninsulated metal ball, was attached to the fulgurating current of the Bovie unit and passed down the bronchus to the desired location. The balled tip was made to lie against the whole bronchial wall and weak desiccating current turned on for 5 seconds. Experience with varying amplitudes of current resulted in our standardizing the dose to the desiccating current at stop 25. Eighteen animals were used. Two of the animals in this series developed bronchial occlusion upon a single cauterization; 2 others developed occlusion after two to four cauterizations. Postoperative hæmorrhage and gangrene of the lung resulted in ten instances. This experiment suggested that its practicability was extremely limited.

Comments. The experience with these three methods, silver nitrate, Carnoy's fluid, and electrical cauterization, showed them to be fraught with considerable danger as well as unreliable in the production of occlusion. Such methods seemed too crude, and either pro-

Fig. 3. Animal No. 29-33. Complete atelectasis of the right middle, lower, and accessory lobes. The heart is entirely within the right chest cavity and the right diaphragm is high. This animal was treated twice with acriflavine solution endobronchially. This film was taken 34 days after the first treatment.

duced large ulcerations on the bronchial wall with the subsequent danger of infection and hæmorrhage, or insufficient damage to produce occlusion. It would appear that in order to produce a permanent bronchial occlusion by a safe method, the substance, when applied to the bronchus, should penetrate deeply to the peribronchial tissues and there, acting slowly and over a long period of time, produce a peribronchial fibrosis. There should be a minimum of damage to the bronchial wall and to the pulmonary tissue distal to the application. If the procedure is to be of value clinically it should be efficient enough to produce occlusion of the bronchus to the lobe of a dog's lung upon one or, at most, two applications, and should be able to occlude the main primary bronchus after two or three applications.

In the search for such a substance to produce bronchial occlusion, it was recalled that painless strictures of the urethra were not uncommon following irrigations with acriflavine solution. If diluted acriflavine in the urethra was capable of producing such marked periurethral fibrosis as stricture, its fibroblastic processes elsewhere were worth investigating. Erdheim found that this dye, when injected directly into tissues, produced an area of aseptic necrosis, the periphery of which was surrounded by marked granulation and fibroblastic tissue. This dye is known to possess great powers of penetration, and experimental work has shown that following an urethral irrigation the dye is grossly present in the periurethral tissues.

These many considerations led us to believe that this drug in greater concentrations might have the desired action on the bronchus. A series of dogs were then tested with acriflavine of various concentrations.

The method. Dogs weighing from 8 to 20 kilograms were used. They were anæsthetized by the intraperitoneal injection of sodium pentobarbital, 0.035 grams of the drug in solution per kilogram weight being used. This anæsthesia proved extremely satisfactory. A deep narcosis could be induced without troublesome cough reflex and without danger to the animal. The animals were fastened supine on the table. The bronchoscope was inserted into the larynx, the carina identified, and the tip of the bronchoscope then pushed down to the position where cicatrization was desired. All bronchi have been subjected to this treatment. Acriflavine was applied to the desired bronchus by moistening a cotton swab, tightly wrapped upon the end of a long stiff wire, with the solution. The excess solution was expressed and the applicator was placed just within the bronchial orifice for from 6 to 10 minutes, the duration of the application depending on the size of the bronchus. It is important that the swab fit snugly into the orifice of the bronchus and thus be in contact with the entire circumference of the bronchus. Upon removal of the swab if there was present in the bronchus any excess secretion, this was wiped dry with a sponge. The treated area following such an application usually appeared a deep scarlet color and its mucosa seemed withered. In the case of the lower right lobe, each of the numerous openings,

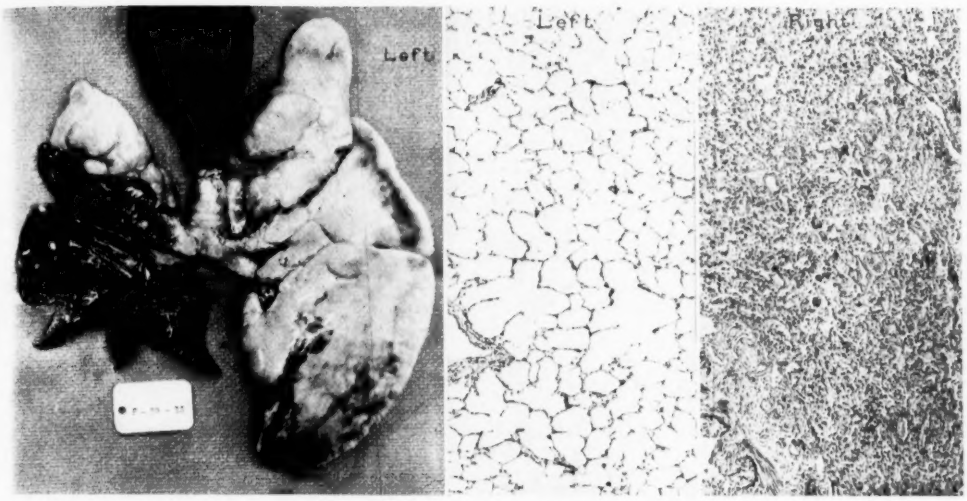

Fig. 4. Animal No. 29-33. Hæmatoxylin and eosin stain gross specimen showing the complete atelectasis of the right middle, lower, and accessory lobes. The X-ray of this animal is shown in Figure 3. The photomicrograph labeled left was taken from the normal left lung. The photomicrograph labeled right was taken from the atelectatic right lung distal to the bronchial occlusion. The magnification is the same in both sections. ×80.

which are ramifications of the lower primary bronchus, were treated in the manner described. If the entire right or left main primary bronchus was to be treated, a cotton wick ½ centimeter by 5 to 8 centimeters, from which all excess of acriflavine had been pressed out with a sponge, was passed through the bronchoscope and packed tightly into the main primary bronchus and left in place for 15 or 20 minutes. Upon removal of the wick the area was carefully wiped to remove any excess solution. Following this method the primary bronchus can be completely occluded, two applications usually being necessary.

The solution of acriflavine should be made up fresh each day that it is used, as exposure decreases its efficiency. If two or more bronchi are to be treated, it is wise to use a fresh cotton applicator for each bronchus, as the secretions moisten the applicator and dilute the concentration of the acriflavine.

A large series of animals were treated with acriflavine. We began by using a 10 per cent solution (7 animals), but soon found the caustic effect was inadequate at this concentration. A summary of the protocols show that one bronchial occlusion (accessory lobe) resulted from a single application and that one occlusion resulted from repeated applications (three applications to accessory or subcardiac lobe). The remaining animals were treated with *25 per cent acriflavine*. In this group occlusion resulted with great regularity when the technique had become standardized. The fatalities are discussed in detail and are sufficiently explainable on technical grounds or other accidents to justify our hopes that a satisfactory and safe method for creating bronchial occlusion has been found.

SUMMARY OF EXPERIMENTS WITH 25 PER CENT ACRIFLAVINE

44 animals.
13 sacrificed before the twenty-first day for histological study of the healing process.
31 animals available for study of occlusion and its risk.
11 died:
- 2 of distemper.
- 3 of gross injury from instrumentation on operating table.
- 1 of fight in kennels.
- 2 of special experiment in which one-half cubic centimeter of fluid was left in bronchus for study of histological reaction in lung.
- 1 of hæmorrhage from sloughing of bronchial wall—this animal was treated twice in the same afternoon for a total of 21 minutes with a free interval.

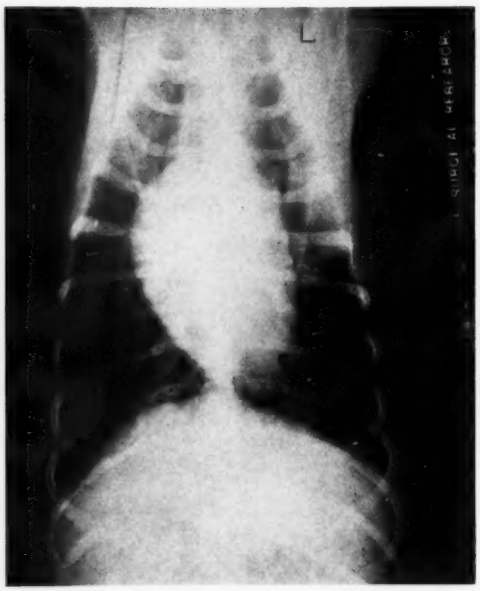

Fig. 5. Animal No. 132-33. X-ray showing normal chest. The diaphragms are similar in position; the lung fields are of equal intensity; the heart apex is just to the left of the midline.

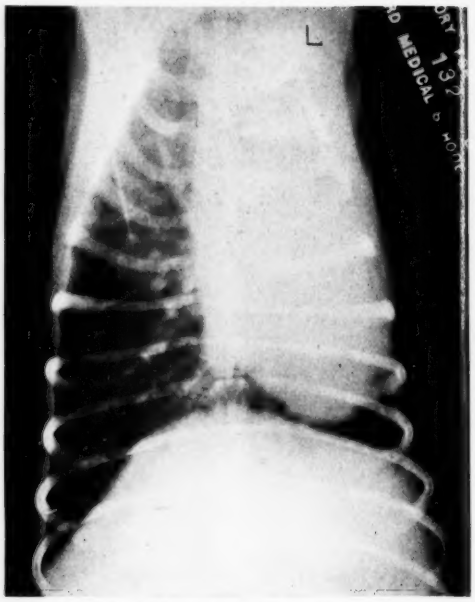

Fig. 6. Animal No. 132-33. X-ray of the chest of the same animal taken 53 days later. Autopsy showed the entire left lung to be atelectatic and airless. The left primary bronchus was treated twice with 25 per cent acid acriflavine solution. The aerated lung which appears just under the heart is the displaced right accessory lobe.

2 of pneumonia which began in the lobe treated by this fluid.

20 survivals for testing efficiency of acriflavine solution in producing occlusion:

In 24 instances occlusion resulted from a single application.

In 19 instances occlusion resulted with from 2 to 3 applications.

The chart which summarizes the experiments with acriflavine shows at least two fatalities in the group of animals which succumbed (those in which pneumonia developed) for which the application of the drug seems directly responsible. Because of the large experience in which a similar unfortunate result did not occur, we feel that in these animals either the fluid applied was excessive and escaped down into the lobe, or we may have been dealing with animals on the verge of distemper. No abscess formation occurred and microscopically we did not observe damage to blood vessels.

All of the different bronchi have been completely stenosed. In several cases the entire lung has been made to collapse completely due to occlusion of all its bronchi. The smaller bronchi are more easily occluded. We found greatest difficulty in collapsing the right lower lobe, probably because its many small bronchi led us to miss one of these during an application, thereby necessitating a second or third application.

The success in the last 20 cases, the histological study of the healing process, and the simplicity of the procedure have encouraged us to the point where we feel justified in progressing to the application of this work to our clinical cases.

PROTOCOLS OF TYPICAL EXPERIMENTS

F-157-33. A brown, mongrel, male dog. Temperature 102 degrees.

March 19, 1933. The dog appeared to be in good condition. A preliminary X-ray of the chest was taken. The dog was anæsthetized with sodium pentobarbital intraperitoneally. The bronchoscope was inserted, and the left primary bronchus was identified. Into each of the divisions of the primary bronchus was inserted for 5 minutes a cotton sponge

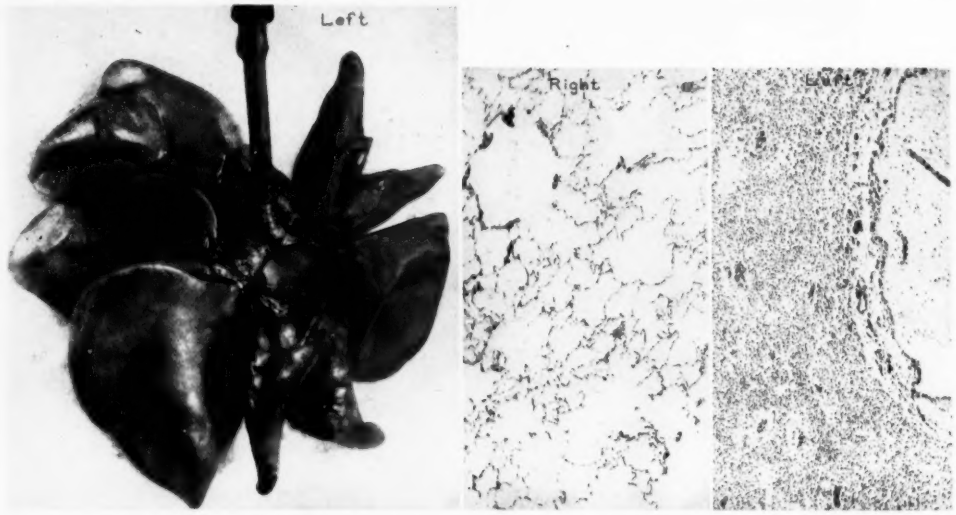

Fig. 7. Animal No. 132-33. The lungs and trachea of a case which had been treated twice with a solution of acid acriflavine. The left lung is collapsed and airless and the left bronchus occluded. The photomicrographs of sections from the right and left lungs are the same magnifications. The photomicrograph of the left shows the alveoli collapsed and airless and the moderately sized tertiary bronchus filled with mucoid material. The vascular supply is intact.

moistened with a 25 per cent acid acriflavine solution. Following this, each of the orifices were reddened and puckered in appearance.

March 21. The dog was up and about in his cage, coughing considerably, but otherwise in good condition. Temperature 102.2 degrees.

March 23. The dog was returned to his cage on the roof. His appearance and actions seemed to be normal.

March 31. The general condition of the animal was good. X-ray of the chest was taken. The dog was anæsthetized and bronchoscoped. The left primary bronchus was identified, and the bronchoscope was inserted into it. The bronchus leading to the upper lobe was still patent, though greatly reduced in size. A 25 per cent solution of acid acriflavine was applied here for 5 minutes. The distal primary bronchus was practically occluded by a marked stenosis, and no other secondary bronchi could be identified. This portion was similarly treated.

April 24. The dog was in excellent condition. X-ray showed the heart almost against the left chest wall, and the left lung almost completely atelectatic. The animal was anæsthetized and bronchoscoped. All of the secondary bronchi were completely stenosed, except one very small bronchus that lay on the floor of the primary bronchus and had not been treated previously. The distal primary bronchus was completely occluded by a firm cicatrix. The small orifice which had not been treated was now treated with 25 per cent acid acriflavine for 5 minutes.

April 25. The dog was up and about, and in good condition. A slight hacking cough was present yet.

May 15. X-ray showed all of the lobes of the left lung to be completely atelectatic, and the heart against the left chest wall. The left diaphragm was high. The dog was bronchoscoped. The left primary bronchus was found funnel shaped and it tapered to a complete occlusion. All of the secondary bronchi were completely occluded.

Intrapleural pressures were taken on both sides which showed no essential variation from normal. On deep inspiration the negative pressure on the atelectatic side fell to minus 12 centimeters of water, and on the normal side to only minus 8 centimeters of water.

Blood gas analysis by the Van Slyke method showed no significant changes.

June 26. Temperature 102.2 degrees. The dog was in excellent condition, ate well, and appeared active and normal. X-ray of the chest (Fig. 1) showed complete atelectasis of the left lung, heart against left chest wall, and left diaphragm high.

June 29. The dog was killed with ether intravenously. The heart and lungs were removed (Fig. 2). The lobes of the left lung were small and shriveled and of a brownish blue color. The lobes were noncrepitant and uniformly firm. The pleura which covered them was entirely smooth and shiny and without adhesions. Cut sections showed a uniformly hepatized appearance. The tissues were firm, nonfriable, and the smaller bronchi, within the lung substance, were filled with a mucoid material.

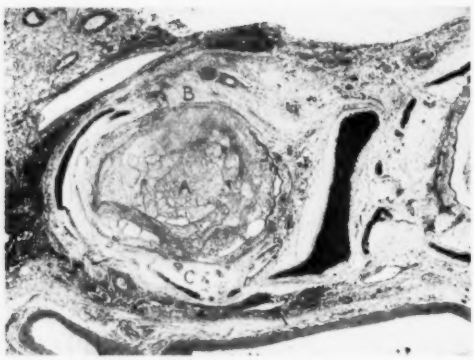

Fig. 8. Bronchus 6 days after treatment. The lumen, *A*, is filled with a firmly adherent mucoid plug. Many of the cartilages, *B*, are necrotic. Submucosa, *C*, homogeneous and undergoing aseptic necrosis. Hæmatoxylin and eosin stain ×10.

Fig. 9. High power magnification of the same bronchus. Hæmatoxylin and eosin stain ×40.

F-29-33. Brown, mongrel dog. Temperature 101.4 degrees.

March 8, 1933. X-ray of the chest showed it to be normal. The dog was fastened to the table, anæsthetized, and the bronchoscope inserted. The right primary bronchus was identified. Each of the branches, except the right upper, was found and treated with a 25 per cent acid acriflavine sponge, which was carefully fitted into the orifice snugly, and left in place for 5 minutes. Following this procedure the primary bronchus was carefully sponged to remove any excess fluid. The treated areas were moderately stained and withered and wrinkled in appearance.

March 10. The dog appeared normal. However, a moderate hacking cough was present. The dog ate well, and played actively with the other dogs.

March 23. X-ray of the chest showed no essential variation from normal. The dog was anæsthetized with sodium pentobarbital intraperitoneally and bronchoscoped. The right primary bronchus was rather markedly constricted so that the bronchoscope was passed into it with difficulty. The orifices of the secondary bronchi, leading to the individual lobes, excepting the right upper, were shrunken, œdematous, but not occluded. There was no erosion

Fig. 10. Bronchus 12 days after treatment. The mucoid case has been separated from the bronchial wall and expelled. There is a marked proliferation of the peribronchial tissues and submucosa. Hæmatoxylin and eosin stain. ×25.

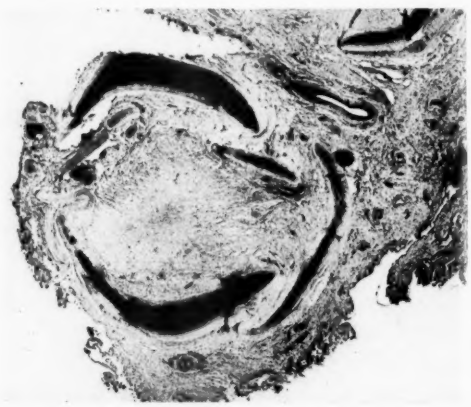

Fig. 11. The occluded bronchus 28 days after treatment. The cartilages are misshapen and displaced. The lumen is filled with granulation and scar tissue. There are present many small epithelial inclusion cysts. The lung distal to this bronchus was entirely atelectatic. Hæmatoxylin and eosin stain. ×10.

of the mucous membrane. Each of the lobe bronchi was treated for 5 minutes with 25 per cent acid acriflavine solution.

April 11. The animal was in good condition. Temperature 102 degrees. X-ray (Fig. 3) showed the right middle, lower, and accessory lobes completely atelectatic, the heart drawn over against the right chest wall, and the right diaphragm high.

May 2. Blood gas analysis by the Van Slyke method showed little significant change from normal. The dog was anæsthetized and bronchoscoped. The right primary bronchus was completely occluded just beyond the carina. The mucous membrane, covering the occlusion, appeared normal. The right upper lobe bronchus was partially occluded.

June 29. The dog was in excellent condition. X-ray of the chest showed the right middle, lower, and accessory lobes completely atelectatic, the heart drawn over against the chest wall, and the right diaphragm high. The dog was killed with ether intravenously. The right accessory, lower, and middle lobes were small, shrunken, and of a dark brownish purple color (Fig. 4). These lobes were completely atelectatic and contained no air. The pleura, everywhere, was smooth and shiny, and there were no adhesions. The bronchi leading to the lobes were small, sclerosed, and felt pipestem-like. The bronchial lumen was completely filled with cicatrix. The atelectatic lung was of uniformly smooth consistency, and the small bronchi within the lobes were filled with a mucoid material.

F-132-33. Female, collie dog. Temperature 101.6 degrees.

March 11, 1933. X-ray of the chest was taken which showed it to be normal (Fig. 5). The dog was fastened upon the operating table and anæsthetized with sodium pentobarbital intraperitoneally. The bronchoscope was inserted into the trachea, the carina identified, and the left primary bronchus entered. All of the orifices of the secondary bronchi which lead from the primary were treated for 5 minutes with a 25 per cent aqueous solution of acid acriflavine, the routine technique being used. Following this the main primary bronchus was packed, for 5 minutes, with a wick which had been soaked in the acriflavine solution, and all of the excess solution expressed. Following this procedure the mucous membrane was stained a deep scarlet color.

March 12. The dog was up and running about. He had a moderate cough, but otherwise his appearance and actions were normal.

March 13. The dog was in good condition. Temperature 102.4 degrees.

March 31. An X-ray of the chest showed no atelectasis, and the heart was in the normal position. Sodium pentobarbital was given intraperitoneally, and the animal was bronchoscoped. The left primary bronchus was markedly constricted so that the bronchi to the individual lobes could not be visualized. The mucosa was intact, and there was no bleeding. The point of stricture in the primary bronchus was treated for 5 minutes with a cotton applicator moistened with a 25 per cent solution of acid acriflavine.

April 2. The dog was in good condition, ate well, and appeared entirely normal.

May 4. An X-ray of the chest showed the heart within the left chest against the lateral chest wall. The left lung was entirely atelectatic and collapsed.

June 20. The dog was in good condition. Temperature 102 degrees. An X-ray (Fig. 6) showed complete atelectasis of the entire left lung, and a high left diaphragm. Intrapleural pressures were taken, which, on the left side, varied from minus 14 centimeters of water to minus 20 centimeters of water. In the right chest the intrapleural pressure varied from minus 8 centimeters of water to minus 13 centimeters of water.

Blood gas analyses by the Van Slyke method showed no appreciable changes.

The dog was anæsthetized with sodium pentobarbital intraperitoneally and bronchoscoped. The left primary bronchus was entirely constricted and occluded 2 centimeters below the carina. The dog was killed with ether intravenously and the heart and lungs removed. The trachea was attached to a rubber bulb and the lungs distended with air (Fig. 7). The right lung ballooned with air, and was entirely normal in appearance. The lobes of the left lung were airless, small, and shrunken, and probably less than one-third of their normal size. The pulmonary tissue was of the same color and consistency as normal liver, but much less friable. Complete atelectasis of the entire left lung was present.

PATHOLOGY

Acriflavine solutions of various strengths were tested upon the bronchi; those solutions of less than 25 per cent proved ineffective. The dye is soluble in water only to 33 per cent under normal conditions, and it was felt that the danger of introducing particles of undissolved dye into the bronchus prohibited the use of any stronger solution. A group of animals treated with 25 per cent solutions of acriflavine were sacrificed at intervals and gross and microscopic studies made:

Two hours. At autopsy the lobe appeared normal in size and color and consistency. The bronchus which led to this was stained a diffuse yellow, and the dye could be seen penetrating to the peribronchial tissues.

One day. The lobe appeared normal. It was crepitant and of normal color and consistency. The bronchus leading to it was slightly stained yellow, the surface appeared swollen and lacked its normal glistening appearance.

Microscopically, the bronchial mucosa and musculature were necrotic and the peribronchial tissues in the immediate vicinity of the cartilages showed a rather homogeneous appearance with a poor nuclear stain. The larger blood vessels showed no damage. The pulmonary tissue in the immediate proximity was rather congested, showed some hæmorrhage, and a few of the alveoli contained a hyaline membrane. Leucocytic infiltration was correspondingly absent. The peripheral lung, except that surrounding the larger bronchi, was entirely normal. The pulmonary tissue encircling these bronchi was congested, and in a few isolated places the alveoli were filled with serum, without cells.

Four to six days (Figs. 8 and 9). At autopsy, the lobe was a deep purplish color and smaller in size than normal. To palpation it was noncrepitant, and seemed rather wet and boggy. There was no evidence of infiltration. The bronchus leading to it was occluded by a mucoid cast which was firmly adherent to the wall. Upon removal of the mucoid plug the orifice of the bronchus was rough, and lacked its normal glistening appearance. Microscopic sections showed the epithelium and submucosa entirely replaced by a mucoid plug which filled the bronchial orifice and was adherent to the submucosa and in places to the pericartilaginous tissues. Many of the cartilages were necrotic. There was considerable granulation tissue and fibroblastic proliferation in the peribronchial tissues. In places there were a few lymphocytes and rare scattered leucocytes. The pulmonary tissues in the immediate proximity showed some organization, with scattered patchy atelectasis. There was slight round cell infiltration. The distal lung was œdematous and showed some patchy atelectasis, but there was found no evidence of inflammation.

Eight to ten days. At autopsy in most instances the lung was somewhat darker in color and was crepitant and air containing. Occasionally one or two patches on the surface were a deeper purple in color, were retracted from the surrounding lung, and did not contain air. The bronchus was open, the mucoid plug having been expelled. The surface of the bronchus was somewhat smooth and shiny, occasionally studded with petechiæ. The lumen was somewhat decreased in size.

Microscopic section showed the surface of the bronchus lined with a thin layer of regenerating epithelium. In one in which the mucoid plug had not yet been expelled the regenerating epithelium was growing between the mucoid plug and the submucosa, separating the two, and loosening the plug. The submucosa and perichondrial tissues were still necrotic and homogeneous, and showed no nuclear stain. There was no cellular infiltration. A majority of the cartilages were extensively damaged. The pericartilaginous tissues showed beginning regeneration with fibroblastic proliferation. The lung surrounding the bronchi showed some patchy atelectasis with scattered blood pigment. Evidences of infection were entirely absent.

Two weeks (Fig. 10). The gross appearance of the pulmonary tissues closely resembled those examined in 10 days.

Microscopically, the sections of the bronchus showed the epithelium to be fully regenerated and without cellular reaction. There were occasional piled up areas of epithelial cells forming polyps. In many places, just under the epithelial layer, were nests of epithelial cells forming little inclusion cysts. There was slight beginning regeneration in the submucosa. The cartilages were necrotic, misshapen, and in many instances, rather markedly displaced from their normal position. The peribronchial tissues showed marked fibroblastic proliferation and regeneration. The lung in a few scattered areas, which tended to follow the bronchial ramification within its parenchyma, still showed evidences of hæmorrhage and congestion. Small zones of patchy atelectasis were still present.

Four weeks (Fig. 11). At autopsy, the lobe was small, shrunken, and of a bluish-purple color. It was rather firm, non-crepitant, and except for the fact that it was not friable, closely resembled liver tissue. It proved to be 100 per cent atelectatic. The bronchi within it were filled with a thick, tenacious mucus. The primary bronchus was entirely occluded for a distance of 8 millimeters. Sections cut through the occluded bronchus showed complete obliteration of the lumen

with granulation and fibrous tissue, in which were interspersed occasional epithelial inclusion cysts. The bronchial cartilages were of a homogeneous appearance and partially degenerated. They were twisted and misplaced, occasionally two and three and even four of them lay side by side. The pericartilaginous and peribronchial tissues were fibrous and dense, and appeared to have compressed and buckled the bronchial wall and cartilages. The peripheral lung (Fig. 4, rt.) was atelectatic, appeared congested and œdematous, but there was found not the slightest evidence of infection.

A solution of acriflavine in the high concentration used in this work produced quite marked local damage in the bronchial wall, with surprisingly little damage to the lung distal to the application or to the surrounding structures. The necrosis is completely aseptic and peculiarly lacking in cellular reaction. The definite fibroblastic reaction in the periphery of the treated area aids greatly in reducing the bronchial diameter by compressing and buckling the bronchial cartilages. Similar aseptic necrosis following the use of other acridine dyes have been described by Milch. Erdheim tested these dyes by injecting them directly into the tissue, and found that peripheral to the zone of destruction there was found a zone of granulation and fibroblastic tissue. The reaction in the case of acriflavine is purely local, as the dye is systemically toxic only in large doses, and may even be given intravenously without harm.

RESULTS AND DISCUSSION

A series of 44 dogs have been studied following the use of acriflavine by this method. Complete gross and microscopic studies have been made at intervals following treatment. There occurred 11 fatalities in this series, the explanation of which shows that in only 2 of these could the solution, as used in our final technique, have been at fault. By repeated applications at a single sitting all bronchi to an entire lung have been satisfactorily occluded. This method, in our experience, has proved surprisingly safe and efficient. In no instance did the collapse of a lung with resultant atelectasis interfere with the animal's general condition. While intrapleural pressures were not constantly taken, the readings obtained in animals with complete atelectasis showed but little alteration from the pressures in normal animals. This, in part, may be explained by the very mobile mediastinum present in dogs. The temperature elevation following application was negligible. In dogs, permanent bronchial occlusion caused in some animals a persistent bronchial cough, while in the 3 monkeys in which stenosis has been induced by this method, cough, even immediately following treatment, was noticeably absent. The human case under treatment, at the present time, has had a postoperative course marked by the absence of bronchial irritation, cough, temperature, discomfort, physical or X-ray changes in the lung.

The occurrence in these experiments of lobar pneumonia following the production of an atelectasis was not seen. Coryllos (7) has contended that lobar pneumonia, even postoperative bronchopneumonia, is preceded by the production of an atelectasis, and that in this airless lung the pneumonococcus infection spreads to produce the typical clinical syndrome. That this theory is not effective in the experimental animal, without the intrabronchial introduction of massive doses of pneumonococcus culture, is evident from a study of these protocols. The atelectasis which occurred in the normal animals was unassociated with fever, malaise, or loss of weight. Microscopically, the airless lung showed no evidences of pneumonitis at any stage. (Figs. 9 rt., 10 lt., and 11 lt.)

CONCLUSIONS

1. A safe and reliable method to produce experimental bronchial occlusion is presented.

2. The theoretical advantages of such a procedure in the treatment of certain forms of pulmonary tuberculosis is considered.

3. Twenty-five per cent aqueous acid acriflavine solution as used in these experiments produced an aseptic necrosis of the bronchial mucosa and submucosa, and the formation of a firmly adherent mucoid plug. Later the rapidly regenerating epithelium separated this from the walls and the plug was coughed out. The peribronchial and submucosal tissues

proliferated, became fibrosed, and occluded the bronchial lumen.

4. Pulmonary atelectasis occurred only when all of the bronchi to the lobe had been completely occluded.

5. Permanent pulmonary atelectasis, even of a whole lung, was compatible with the normal health and good general condition of the experimental animal.

BIBLIOGRAPHY

1. Adams, W. E., Van Allen, C. M., and Livingstone, H. M. Ann. Surg., 1930, xci, 342–360.
2. Adams, W. E., and Livingstone, H. M. Arch. Surg., 1931, xxiii, 500–512.
3. Idem. Surg., Gynec. & Obst., 1931, liii, 479–485.
4. Idem. Ann. Surg., 1932, xc, 106–116.
5. Idem. Arch. Surg., 1932, xxv, 898–908.
6. Blalock, A., and Raymond, W. M. Surg., Gynec. & Obst., 1933, lxvi, 779–781.
7. Coryllos, P. N., and Birnbaum, G. L. Arch. Surg., 1929, xviii, 190–241.
8. Coryllos, P. N. J. Am. M. Ass., 1933, c, 480–482.
9. Idem. Am. Rev. Tuberc., 1933, xxviii, 1–26.
10. Cutler, E. C., and Zollinger, R. Am. J. Surg., 1933, xix, 411–418.
11. Eloesser, L. J. Thoracic Surg., 1931, i, 194–213; 1932, 270–295; 1932, 373–396; 1932, 485–501.
12. Erdheim, S. Arch. f. klin. Chir., 1919–1920, cxiii, 772–809.
13. Farris, H. A. Canadian M. Ass. J., 1925, xv, 808–815.
14. Gatterdam, E. A. Southwest Med., 1931, xv, 311; Seventeenth Annual Meeting of Radiologists, Nov. 3, 1931.
15. Jacobaeus, H. C., and Westmark, N. Acta. Radiol., 1930, xi, 547.
16. Korol, E. Am. Rev. Tuberc., 1931, xxiii, 493.
17. Milch, H. Ann. Surg., 1928, lxxxvii, 95–98.
18. Novy, F. G., and Soule, M. H. J. Infect. Dis., 1925, xxxvi, 168.
19. Packard, E. N. Am. Rev. Tuberc., 1928, xviii, 7; Tr. Am. Clin. Ass., 1930, xlvi, 225.
20. Schlaepfer, K. Arch. Surg., 1923, vi, 358–360.
21. Stoloff, E. G. Am. J. Dis. Child., 1928, xxxv, 239–249.
22. Zollinger, R., and Moritz, A. R. Arch. Neurol. & Psychiat., 1932, xxviii, 1046–1055.

THE MECHANISM OF DEATH IN MASSIVE PULMONARY EMBOLISM

With Comments on the Trendelenburg Operation

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DEATH from massive pulmonary embolism is such a dramatic incident that descriptions of the clinical picture are commonplace. However, the very fact that the event is so unexpected and tragic has colored the observations with inaccuracies and it is exceedingly difficult to find an adequate clinical analysis of what really may take place. This dearth of knowledge is reflected by the well known discrepancy between the clinical diagnosis of pulmonary embolism and the autopsy findings—perhaps in no other condition do hospital statistics show a greater percentage of error. In many clinics the sole fact that a patient dies unexpectedly and abruptly following a surgical operation gives ample grounds for the diagnosis. One calls to mind the diagnosis of "heart failure," formerly made with such frequency and parallel inaccuracy.

One of the best expositions of the signs and symptoms of pulmonary embolism is to be found in the paper of Giertz and Crafoord, based on a statistical analysis of the clinical picture presented by 27 patients. In 23 instances the condition was correctly diagnosed before death. The symptoms observed were, in order of frequency, as follows: sudden onset of symptoms without any warning; high, soft, imperceptible pulse; marked pallor; unconsciousness; slight cyanosis; craving for air; dyspnœa; altered respiration, superficial or deep; snatching or groaning; feeling of oppression, dread, anxiety, restlessness; pain, or stitch in chest, usually over precordium; "shock," cold perspiration; pulsations in veins of neck (the authors remark that this symptom is probably more frequent than was noted in the brief accounts available); waving arms about, wanting to get up. Violent vomiting, strabismus, dilated pupils, giddiness, and yawning also occasionally occur. The symptomatology is summarized as follows: "In most instances it (massive pulmonary embolism) comes like a bolt from the blue with typical symptoms of which the most frequent are intensive pallor, loss of pulse and consciousness. Common symptoms are also oppression, craving for air and a mild cyanosis with a typical venous pulsation above the clavicles" (1).

It is obvious that the enumerated signs and symptoms represent a composite picture drawn from a group of cases and that in any individual instance many of these findings will be absent. In order to furnish a background for the interpretation of the varying clinical aspects, it has been found helpful to define at least 3 mechanisms by which death is produced, when a large thrombus is carried through the right heart and lodges in the pulmonary artery. It is evident that the duration of life and the symptomatology will depend upon the amount of obstruction that the embolus produces in the particular case under consideration.

I. COMPLETE OBSTRUCTION WITH IMMEDIATE DEATH

A large thrombus that completely blocks the outflow from the right heart will cause immediate but not instantaneous death from complete cessation of the circulation. The left ventricle continues for a moment to discharge the blood that is already present in the pulmonary circuit and then its output abruptly ceases. There is a loss of conscious ness due to cerebral anæmia and after a few asphyxial gasps the respiratory center fails completely. The lack of coronary blood supply resulting from the fall of pressure in the aorta increases the dilatation of the right heart already precipitated by the obstruction of the outflow of blood.

It is impossible at the present time to estimate in percentage values just the degree

of occlusion of the artery that is followed by immediate death. In any event, it is probable that there exists a wide variation in the response of different individuals due to differences in age, condition of the cardiac musculature, the state of the peripheral circulation and other factors.

II. PARTIAL OBSTRUCTION WITH DELAYED DEATH DUE TO REDUCED EFFECTIVE BLOOD VOLUME

In many cases occlusion of the arterial lumen by the embolus may be so far from complete that the circulation is carried on for some time, although under a mechanical disadvantage that ultimately leads to death. It is this type of case that offers an opportunity for pulmonary embolectomy.

For many years, in fact dating from experimental observations by Cohnheim, the statement has been made in the literature that if the pulmonary artery be slowly occluded, no effects are discerned until a point is reached at which an abrupt failure of the circulation terminates in immediate death. Gibbon, Hopkinson and Churchill showed that this phenomenon was an artifact produced by the experimental methods commonly employed. It was further demonstrated that partial occlusion of the artery produced a period of diminished cardiac output with falling arterial pressure and rising venous pressure. This state of affairs closely simulates the well known effects of cardiac tamponade with the difference that the point of obstruction is in the pulmonary artery rather than at the right auricle or intrapericardial portions of the cavæ.

These experimental findings are not infrequently reproduced in the clinic when only a partial obstruction to the flow of blood in the pulmonary artery is produced by the embolus. The following case history is as instructive as an experimental protocol in illustrating this point.

E. S., an obese woman, aged 53 years. Following cholecystectomy there was slight fever attributed to minor wound sepsis. No signs of femoral phlebitis were noted. On the fifteenth postoperative day at 3:00 p.m. after the patient had been taken to the lavoratory in a wheel chair and returned to bed, she had a "queer" feeling in her right chest, "like a lump," which almost at once developed into a sharp pain. When seen a few minutes later she was lying propped up in bed, pale, apprehensive, and laboring for breath. She was retching, nauseated, and bathed in cold sweat. The pulse was rapid and thready. The lips and fingernails were pale and slightly dusky. The blood pressure was 100/60 as contrasted with 150/90 recorded on admission to the hospital. A diagnosis of massive pulmonary embolism was made, oxygen inhalation was started at once through a nasal catheter and morphine sulphate, 1/6 gram, given hypodermically. Following these preliminary measures the patient was transported to the surgical amphitheater in her bed. Preparations for immediate operation were completed and the patient was kept under constant observation with this in view. The accompanying chart (Fig. 1) shows the subsequent course of events.

During the first hour after the embolism, the blood pressure fell steadily. For the next 2 or 3 hours there was little change in the general condition of the patient, the cyanosis was less obvious and the respiration quieter. There were occasional spells of vomiting, retching and eructation of gas, interspersed with intervals of drowsiness. At 9:00 p.m., 6 hours after the onset, the patient's condition was considerably improved. Both systolic and diastolic pressures were higher and the respiratory rate was slower. These encouraging signs persisted for about 4 hours. At 1:00 a.m., 10 hours after the embolism, there was a decided change for the worse. The blood pressure fell. Symptoms of air hunger reappeared. The respiration became deep, and more rapid and the patient repeatedly attempted to sit up in bed. The anxiety and apprehension of a person dying of hæmorrhage were apparent in her face. The patient was placed on the operating table and the operating team made ready for interference.

From this time on the patient slowly lost ground. Her restlessness increased. She attempted to sit up on the operating table, and repeatedly asked for water. The air hunger, the restlessness, the thirst, the low blood pressure with a feeble, rapid pulse and the cold perspiration were remarkably similar to the symptoms that attend a severe hæmorrhage. This impression was so vivid that we repeatedly examined the abdomen for signs that might confirm a diagnosis of concealed hæmorrhage. There was, however, one striking difference between the picture she presented and that of a patient dying from hæmorrhage. *The great veins in the neck became increasingly prominent and a venous pulsation was plainly visible.* Consciousness began to be dulled although the facies remained apprehensive and the patient responded to questions. Purposeless movements appeared—plucking at blankets, turning head from side to side. An external strabismus developed.

At 7:04 a.m. venesection was performed. Blood was withdrawn by syringe from a vein in the right ankle. The blood did not flow out under pressure, but was withdrawn slowly and with some difficulty.

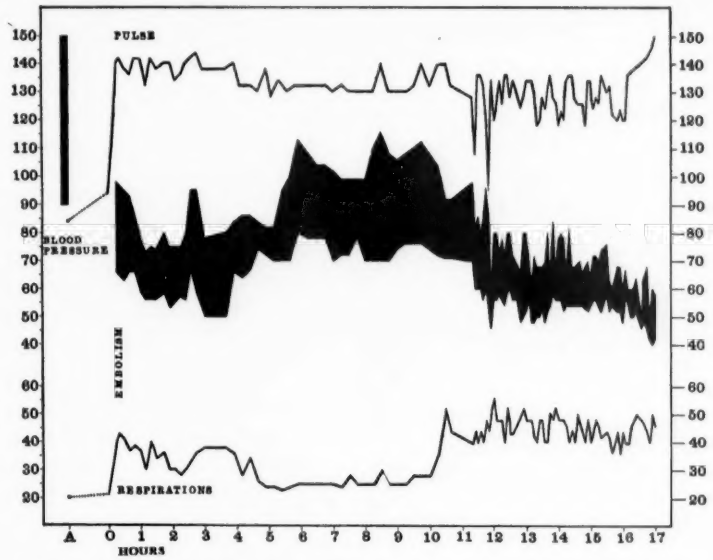

Fig. 1. Clinical chart of patient during the 17 hour interval between a massive pulmonary embolism and death. Systemic blood pressure recorded in solid black, the upper border of which represents the systolic and the lower border the diastolic level in millimeters of mercury.

By 7:37 a.m. 520 cubic centimeters had been withdrawn and citrated in anticipation of reinjection. The patient's condition failed rapidly during this period. The pulse could no longer be counted at the wrist. The blood pressure readings were difficult to obtain and there was considerable decrease in pulse pressure. Examination of the chest at this time revealed that the lungs were resonant anteriorly and laterally. The patient was not turned to examine the back. The breath sounds were harsh, but no râles were heard. The area of cardiac dullness was unchanged. By percussion the right cardiac border lay 1.5 centimeters lateral to the right sternal border. The heart sounds were very distant and could be heard only over the third and fourth left interspaces near the sternum. At 8:00 a.m. the blood pressure was 58/42. The pulse rate counted with the stethoscope over the precordium was 150 per minute. The respiratory rate was 48 and the patient was semicomatose. At 8:05 a.m. the blood pressure could not be obtained. One minute later the skin incision was made and the Trendelenburg operation started, following in essential details the technique described by Meyer (4). The respirations became gasping with the start of the operation and soon ceased altogether. The pupils dilated. By the time the pericardium was opened, heart action had ceased. Seven minutes after the start of the operation clots had been removed from the main stem and both branches of the pulmonary artery and the opening in the artery had been closed with the Trendelenburg clamp. Artificial respiration with inhalation of oxygen and carbon dioxide was kept up while attempts to restore the heart action by massage and injections of adrenalin were made. All efforts to revive patient, however, proved futile.

An autopsy was performed 3 hours later. The great veins contained no blood clots. The coronary arteries were patent. There were no antemortem clots within the heart or main trunk of the pulmonary artery. In the left pulmonary artery about 4 centimeters below the bifurcation of the main trunk there was a grey, friable antemortem clot extending down into two or three of the smaller branches of the artery. This clot obstructed only a portion of the artery and was lightly adherent to its wall. The right pulmonary artery was free of antemortem clots except for a small thrombus 2 centimeters long in a superior branch of the artery.

In retrospect, and particularly in light of the experimental work already referred to, the mechanism of death in this case seems clear. The initial embolism reduced the output of the right heart and consequently that of the left by mechanically obstructing the flow of blood in the pulmonary artery. The blood backed up behind the site of obstruction filling and distending the venous system. The patient developed the clinical picture of

shock from a reduced effective blood volume. The sympathico-adrenal system was thrown into a state of intense activity with its classic train of symptoms, and death supervened as in hæmorrhage or other conditions that are attended with an inadequate circulating blood volume. It is quite probable that the high venous pressure with the peripheral stasis that accompanied it resulted in a movement of fluid from the capillaries into the tissues, thus further reducing the blood volume.

It is possible that the degree of obstruction produced by the initial embolism was augmented during the succeeding hours by other smaller thrombi or by clot propagation within the pulmonary vessels, but no direct evidence exists on this point.

This case provides a slow moving-picture of a series of events that usually follow one another so closely that they cannot be isolated for analysis.

III. PARTIAL OBSTRUCTION WITH DELAYED DEATH IN WHICH RIGHT HEART FAILURE IS A COMPONENT

In descriptions of the Trendelenburg operation it is frequently stated that the pulmonary artery appears markedly dilated when the pericardium is opened. We ourselves have seen it so distended as to impinge upon the under surface of the sternum. Two cases have been encountered, however, in which the pulmonary artery was *collapsed* rather than distended, although the heart was still beating. As the diagnosis of embolism was verified in each instance this finding can only mean that following an initial insult the right heart was unable to maintain a head of pressure sufficient to distend the artery proximal to the obstruction; or that by the time the operation was performed the obstructing thrombus had moved on toward the periphery of the lungs. In either event the patient was dying not of obstruction to blood flow, but from failure of the right heart, precipitated by the embolus. It seems obvious that the competency of the cardiac musculature to meet the strain of a sudden partial occlusion of the artery may play a real rôle in the mechanism of death. It would be of utmost importance to recognize such a state of affairs clinically as efforts might well be directed toward the restoration of a dilated and failing right heart rather than toward the removal of an embolus that played an important but transient rôle in the disaster. Just how such a condition is to be recognized except by inspection of the pulmonary artery is difficult to see at the moment. It is planned however, should a collapsed pulmonary artery again be exposed, to direct the immediate efforts toward restoring the heart by methods other than removing the embolus. This could well be done by a liberal bloodletting directly from the pulmonary artery and the injection of adrenalin, with the maintenance, of course, of an adequate supply of oxygen.

The indication for venesection in the treatment of pulmonary embolism may well be mentioned at this point. If the right heart is dilated and failing, then venesection may aid it to recover its competency, even with the embolus still *in situ*. On the other hand, with an obstructing thrombus in the pulmonary artery, and a high head of pressure built up by the right heart that is acting to force blood past the obstruction, venesection can only be harmful by reducing this head of pressure. Venous pressure will be lowered, it is true, but only at the expense of a reduction in what is already a dangerously ineffective cardiac output. So unless a true understanding of the situation can be reached and it is doubtful whether it can be clinically, it seems wise to refrain from venesection in the treatment of pulmonary embolism.

THE TRENDELENBURG OPERATION

The surgeon contemplating the performance of the Trendelenburg operation when the occasion may arise must concern himself with many things: prompt and certain diagnosis, an organization for handling the situation as the most pressing of emergencies and finally, the technical performance of an exceedingly difficult and specialized procedure.

A great number of failures must inevitably attend the bold attempt to deal with major pulmonary embolism by direct operative interference and there is no doubt that the ultimate solution of this distressing complication of surgery must be found in the preven-

tion of the initial postoperative thrombosis. However, lives have been saved by the operation, and until our knowledge of preventive measures is more perfect the surgical treatment of pulmonary embolism must command attention. The recent revival of interest in the Trendelenburg operation for massive pulmonary embolism followed the report of a successful case by Kirschner in 1924. Within a short time accounts have been published of other cases in which the operation was a life saving measure. Meyer, Nyström, Crafoord and other European surgeons have successful cases to their credit, but to date no survivals have been reported from America.

Many well considered modifications of the original technique have been suggested by Meyer and by Nyström and we may look forward to further suggestions as the operation is taken up by other hands.

It is not our privilege to discuss the technical features of the operation on the basis of unsuccessful cases, but we venture a few comments, some of them merely in corroboration of the suggestions of Meyer or Nyström.

1. Opening the pleural cavity is an error of technique to be carefully avoided.

2. Given time, development of the skin flap with resection of the ribs and costal cartilage and ligation of the internal mammary vessels may suitably be done under local anæsthesia as a preliminary step.

3. The original Trendelenburg sound is needlessly large and clumsy, the clamp for closing the artery far too crude. Modified instruments have been found more suitable.

4. Fragments of emboli that cannot be grasped by the forceps can be removed from the artery by a suction tube.

5. An apparatus for carrying on artificial ventilation with oxygen under positive pressure should be at hand, preferably an intratracheal insufflation cannula as devised by Flagg.

Although our enthusiasm is somewhat dampened by a series of 10 failures,[1] we shall continue to recommend the Trendelenburg operation under favorable circumstances. The following facts are held constantly in mind: (1) Certain patients rally from the initial effects of embolism, and eventually recover from what was apparently a moribund condition. (2) Death may be impending from right heart failure initiated by an embolus, the mechanical effects of which have been transient. (3) Diagnosis is difficult. (4) The operation is technically difficult and hazardous.

[1] In 2 cases the Trendelenburg operation was by Dr. James C. White.

Nyström wisely advises the postponement of operative interference until the patient is at the point of death. When uncertainty exists as to the diagnosis and prognosis this is undoubtedly the course to be pursued. It is obvious, however, that in the face of the gross damage to the circulation produced by a massive embolus, any unnecessary delay will materially lessen the chances of success. A study of the clinical course of certain patients has emphasized this point, for certainly at times in our hands the procedure could perhaps be more properly termed an immediate postmortem examination than a surgical operation. If the time of the operation is to be advanced, a greater responsibility is to be assumed by the surgeon, and a greater surety in diagnosis must be developed. With this in view, an effort has been made both in the clinic and the laboratory to gain a better understanding of the nature of the underlying disturbance of the circulation. When such a concept is clearly established the signs and symptoms observed at the bedside become more intelligible, and the indications for operation more readily discerned.

REFERENCES

1. Gibbon, John H., Jr., Hopkinson, Mary, and Churchill, Edward D. Changes in the circulation produced by gradual occlusion of the pulmonary artery. J. Clin. Invest., 1932, xi, 543.
2. Giertz, K. H., and Crafoord, Clarence. Thromboembolic disease and its surgical treatment. Acta Chir. Scand., 1928, lxiv, 121.
3. Kirschner, M. Ein durch die Trendelenburgische Operation geheilter Fall von Embolie der Art. pulmonalis. Arch. f. klin. Chir., 1924, cxxxiii, 312.
4. Meyer, A. W. Erfolgreiche Operation der Embolie der Arteria pulmon. Arch. f. klin. Chir., 1927, cxlviii,313.
   Ibid. Deutsche Ztschr. f. Chir., 1927, ccv, 1.
   Idem. Eine weitere erfolgreiche Lungenembolie Operation. Deutsche Ztschr. f. Chir., 1928, ccxi, 352.
   Idem. Operative treatment (Trendelenburg) of embolism of lungs. Surg., Gynec. & Obst.,1930, l, 891.
   Idem. Eine weitere (meine vierte) erfolgreiche Lungenembolieoperation (neues zur Technik). Deutsche Ztschr. f. Chir., 1931, ccxxxi, 586.
5. Nyström, G. Drei nach Trendelenburg operierten Fällen von Lungenembolie. Acta Chir. Scand., 1928, lxiv, 110; Arch. f. klin. Chir., 1928, clii, 450.

UNATTACHED RETROPERITONEAL FIBROMA[1]

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REPORT OF A CASE

THERE is prevalent among many medical men an impression that the majority of retroperitoneal tumors, unless growing from or involving the kidney, are sarcomata. The fact that many of the patients suffering from retroperitoneal tumors lose weight very rapidly, the decline of the patient being synchronous with a period of rapid growth of the tumor, further adds to this conception. As a result a large number of patients afflicted with the disease are either not treated surgically or if treated are too frequently condemned by the operating surgeon for lack of understanding of the true nature of the tumor.

My experience during the past few years has led me to believe that a considerable number of retroperitoneal tumors are not sarcomata and that their removal is possible although at times fraught with considerable hazard because of their size. I have had the opportunity to see 5 cases within a period of less than 2 years. One was a pure lipoma; 1, an enormous fibrolipoma weighing 64 pounds; 1, a pure fibroma; 1, an echinococcus cyst the size of a medium sized grape-fruit; and 1, a sarcoma. In all these cases the patients were operated upon, and 3 were cured. The case with the large fibrolipoma and the one with the sarcoma came to autopsy soon after exploration.

The opportunity thoroughly to study the case presenting the fibroma dura leads to the presentation of the subject.

F. L. E., white male, aged 31 years, came under observation on October 16, 1932, complaining of an enlargement of the abdomen. The family history, habits, and the marital history were negative. There was nothing in the past history of consequence except an automobile accident in 1928 at which time he suffered a bilateral fracture of the clavicles.

Approximately 5 years ago patient first noticed attacks of fullness in the abdomen which he attributed to gas in the intestines. These attacks were of little consequence and came at intervals. One year ago he began having attacks of abdominal cramps which affected the upper abdomen. They occurred practically every day, were irregular as to the time of appearance, and did not seem to be associated with the taking of food although they were more likely to occur after meals. The cramps were at times relieved by a bowel movement or the passing of flatus. Soda or alkalies did not relieve the pain, and he noted that the taking of more food increased the pain rather than relieved it. His bowels were, as a rule, constipated and the stools were frequently hard. He had never been jaundiced and the appetite was good. There was no discomfort with urination. About 6 months before entering the hospital he first noted a tumor mass in the left side of the abdomen. Upon close questioning, the patient stated that he thought the left side of the abdomen had been more prominent the past 3 or 4 years but he paid little attention to this fact. However, during the past 6 months there had been a distinct and progressive enlargement. During the period of 2 or 3 months before entering the hospital he was much annoyed by the abdominal distention which caused him shortness of breath when lying down or when exerting himself; moreover, the pain had been more severe and frequent and distinctly of a cramp-like nature. Any constriction such as a belt about the abdomen was uncomfortable. He perspired at night, became very nervous, and tired easily.

Physical examination. The general examination revealed an adult white American male about 32 years of age who did not appear to be critically sick. He was somewhat ill at ease and apprehensive. Temperature was 97.6 degrees; pulse, 72; and respirations, 16. He weighed 158½ pounds. His highest adult weight was 171 pounds in 1919 and lowest 147 pounds in 1926. His weight 1 year before was 160 pounds. The physical examination, aside from the abdomen, was negative except for some infected teeth, slight nasal obstruction, and a moderate enlargement of the thyroid gland.

The abdomen was quite protuberant but no dilated veins could be seen in the abdominal wall. There could be felt a firm, rounded, fairly regular mass which occupied the left side of the abdominal cavity and extended to the right side of the abdomen for a distance of 3 inches at the level of the umbilicus. Its lower margin crossed the midline about 2 inches below the navel and extended well down into the left lower abdomen. The flank on the left side was bulging but the protuberance was more anterior than posterior. The mass had no respiratory excursion, being fixed and extending high up under the costal margin. Along the anterior right surface of the tumor could be felt a notch. Crossing the anterior surface of the tumor there could be felt a sausage-like mass which had slight movability and gave one the impression that it was the transverse colon. The spleen and liver could not be palpated.

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Rectal examination was negative. No enlarged lymphatic glands could be palpated and there was no œdema of the extremities or scrotum.

Laboratory data. The electrocardiogram was essentially normal. Two Wassermann tests were negative. Five urinary examinations failed to reveal any pathological findings. The red blood cells numbered from 4,120,000 to 4,710,000, leucocytes from 6,700 to 8,300, hæmoglobin 80 to 85 per cent. The differential white count was within the normal percentages. No pathological cells were found. The coagulation time of the blood was 5 minutes. Blood non-protein nitrogen was 30.9; creatinin, 1.6; and blood sugar, 92.3. Examinations of three specimens of fæces showed no blood, mucus, parasites, ova, or protozoa. Fractional gastric analysis revealed a low acidity; the free acid ranging from 0 to 12 and the combined acid from 10 to 24. Blood was reported in one specimen. The urine dilution and concentration tests were within the normal. Thirty per cent of the dye was eliminated in 2 hours.

A roentgenological examination of the gastro-intestinal tract showed that the barium passed the œsophagus without resistance. The stomach was on the right side and was pushed over almost to the right lateral abdominal wall (Fig. 1). The curvatures were regular. The duodenal bulb filled and showed no evidence of abnormality. The small bowel was displaced to the right and downward so that the left side of the abdominal cavity appeared to be empty. The colon with a barium enema revealed the splenic flexure at the level of the crest of the ileum, the transverse colon coursing abruptly to the right and ascending to the right of the spine (Fig. 2). A 5 hour film showed a small gastric residue (Fig. 3). Pyelography with the intravenous dye revealed a normal kidney pelvis on the right side but none was visible on the left side (Fig. 4). Roentgenological examination following retrograde pyelography revealed a normal right kidney but on the left side the catheter passed upward to the level of the third lumbar vertebra. At this point it took a sharp bend to the right and proceeded downward along the right side of the spine. The injection of the left kidney pelvis showed a dilated pelvis overlying the intravertebral disc between the fourth and fifth lumbar vertebræ and to the right of the spines of the vertebral bodies (Fig. 5). It was evident that the left kidney was pushed downward and to the right by a mass occupying the left retroperitoneal space. The same mass displaced the stomach to the right and the intestines downward and to the right.

A brief summary of the study of this case revealed the following: A large abdominal mass which displaced the intestines and the kidney downward and to the right. This mass had been present for 6 months as far as the patient knew but had caused symptoms, if the history is correct, for approximately 5 years. The mass was fixed and large. There were no other physical findings of note except an enlarged thyroid gland. The patient's general condition was good although he had lost some weight. There was no evidence of a cachexia. The blood and urine were normal.

An enlarged spleen was ruled out on the basis of the displacement of the left kidney, and, because of the peculiar and characteristic shifting of the gastro-intestinal tract, the tumor was believed to be retroperitoneal. With the long history of symptoms and the relatively good condition of the patient the tumor was believed to be a benign one and a diagnosis of retroperitoneal lipoma was made because of the relative frequency of this type of tumor among the retroperitoneal group.

The patient was operated upon November 9, 1932, under spinal anæsthesia. An incision was made extending from well out in the left flank, transversely to beyond the midline, 1 inch above the umbilicus. The muscles were sutured to their fascia as they were cut. The peritoneal cavity was opened at the reflection of the peritoneum along the anterior surface of the tumor. The spleen was normal in size and pushed high up under the diaphragm. An accessory incision was made upward from about the middle of the left rectus muscle to the costal margin giving an adequate exposure. The posterior peritoneum with the descending colon was separated from the tumor by blunt finger and hand manipulation. The tumor appeared to be smooth and rather loosely attached to the surrounding structures so that it could be separated quite easily. Because of the enormous size of the tumor it had to be enucleated blindly, the hand being introduced around it. At the upper pole of the tumor the procedure was quite difficult because of the tight compression of the tumor against the diaphragm; however, with care and without force, the line of cleavage being followed, the tumor was finally completely freed. In spite of a very large incision and with good relaxation of the abdominal wall, the tumor had to be pried out at the lower pole and then, being grasped, it was withdrawn. When the tumor was delivered it was found that a strand of loose areolar tissue containing two veins, which were approximately one-half inch in diameter, led from the posterior peritoneum to the tumor. These veins were ligated and cut, thus completely freeing the tumor. It was interesting to note that the veins did not course over the surface of the tumor but emerged from the tumor by a sharp right angle turn without any surface contributaries (Fig. 6).

The right kidney was found lying low in the abdominal cavity but it readily assumed its normal position; in fact, all intra-abdominal structures resumed their relatively normal positions so that before an attempt was made to close the incision the enormous cavity which had been occupied by the tumor was completely obliterated. After a few small vessels were ligated the field of operation seemed dry. The incision was closed by interrupted catgut sutures and, strange to say, some difficulty was encountered because of tension. A Penrose drain was placed in the lower end of the wound. The early convalescence was uneventful and there was little

drainage. Twelve days after the operation the patient began complaining of pain in the left lower chest and the left upper abdomen and a slight fever was present. Upon examination an area of dullness was found in the left lower chest. It appeared that there was either an accumulation of fluid in the left pleural cavity or the diaphragm was pushed up by some process. A roentgenological examination was interpreted as some process elevating the dome of the diaphragm on the left side. A cautious exploration was made of the left subphrenic space but no evidence of subphrenic pathology could be found. A needle was then introduced into the left pleural cavity and dark bloody turbid fluid was aspirated. This fluid yielded a positive culture of Staphylococcus albus. A rib resection was done and drainage was instituted. Subsequent to this with lavage of the intrathoracic cavity the fluid escaped through the abdominal wound indicating a perforation of the diaphragm. The process gradually subsided so that within a period of 2 months the wound was practically closed. The patient gained materially in weight and felt quite well. We are unable to explain the perforation of the diaphragm.

A study of the tumor showed it to be well encapsulated. Its surface was relatively smooth and there were no vessels coursing over the surface. It was firm to touch. It measured 32 centimeters in length and 68 centimeters in circumference and weighed 16½ pounds (Fig. 7). On cut section the surface was found to be white and firm with no areas of degeneration. Microscopically the tumor was everywhere composed of long spindle shaped cells with slender, deeply staining nuclei and relatively little cytoplasm (Fig. 8). The microscopic picture varied somewhat in different parts of the mass. In places the nuclei were few in number and the cells were separated by thick wavy fibrillæ which stained deep red with Van Gieson's, and dark blue with Mallory's aniline blue stains (Fig. 9). Scattered through the sections were areas in which the cells were more numerous and the intercellular substance less abundant (Fig. 10). In other locations the cells were separated by spaces filled with thin, homogeneous, very palely staining material—œdema (Fig. 11). Blood vessels were not numerous and their walls were well formed and normal in appearance. No mitoses and nothing that could be identified as nerve tissue could be found in the sections.

This tumor is therefore a pure fibroma growing in the retroperitoneal space and because of its loose attachment can be classed as unattached.

In discussing the subject of retroperitoneal fibroma, those tumors obviously arising from the kidney, adrenals, or the retroperitoneal lymph glands either primarily or secondarily as metastases will not be considered. However, the benign tumors such as lipoma, fibromyoma, neuroblastoma, teratoma, and cysts must be included because of the similarity of the clinical symptoms and the question of the origin of the tumor.

ETIOLOGY

According to Ewing the origin of most fibromata is still a question. He believes it possible that some take their origin in misplaced islands of tissue as suggested by Cohnheim and calls attention to cases of fibroma of the testes in which elements suggesting that the tumor represented a one-sided development of a teratoma were found. This latter suggestion has a close bearing upon retroperitoneal fibromata as will be mentioned later in this paper. Ewing mentions a second group which may follow local irritation or disturbances in nutrition. In this group may be mentioned keloids, papillary fibromata, and adenofibromata of the mucous membranes associated with catarrhal inflammation and fibromata of the periosteum and joint areas which follow repeated trauma. In the third group, according to Ewing, the clinical features point to a congenital or acquired predisposition, multiple neurofibroma being the best example.

The mixed nature of most retroperitoneal tumors strongly suggests an origin upon a congenital rest basis. Moreover, the frequency of tumors such as teratomata and dermoid cysts in this region further strengthens the theory. Bonnet directs attention to the close relationship between various mixed tumors, embryoma, dermoid, teratoma, and abortive parasitic structures and concludes that the difference is more a relative matter than one of principle.

When one considers the embryological relationship of the retroperitoneal structures it becomes apparent that the theory of Bonnet and Marchand is not far fetched. Kuester, in his book on the surgery of the kidney, states that in the latter part of the second month of the human embryo the entire space between the diaphragm, pelvis, and the spine is occupied by the adrenals, kidneys, and reproductive glands. The adrenals and reproductive glands are so large as to cover the kidney completely. While the kidney remains in its position and increases in size, the adrenals take a higher position and increase little if any in size. With the increase in the length of the body the

reproductive glands begin their descent—not increasing in size as rapidly as do the kidneys—and become differentiated into testes and ovary; by the fifth month they lie in the inlet of the pelvis well out of the original zone. Goebell states that during the re-arrangement of these organs parts of the adrenals or reproductive glands may become detached and remain in the retroperitoneal space. Accessory ovaries have been found and Wiesel states that in 76.5 per cent of the male newborn accessory adrenals or epididymal structures are to be found. In the amphibians, accessory adrenals are exceedingly common.

Schwalbe cites two possible explanations for tumor formation from retained fetal structures. The retained cells have the prospective potential and the prospective tendency to form tumors. He cites as an example of the biological principle, the inactive tooth anlage in the fetus which lies dormant for from 6 to 25 years having during this time the potentialities to form a tooth. Secondly, the retained cells have the potential to form only a tumor and remain latent. At some time through either chemical or physical stimuli they may become activated and form tumors.

There is an evident possibility for the tumor to be originally of a mixed type and later due to either an overgrowth of one type of tissue due to its inherent tendency to grow or to a stimulus of some other nature, it may take on the cellular characteristics of a pure tumor. The specific original cells may supply the stimulus to growth.

In the case reported the tumor derived its blood supply or at least drained its blood supply through vessels attached to the posterior peritoneum; therefore it may be postulated that the tumor originated in some tissue elements of the peritoneum. It is known, however, that the tissue lying between the leaves of the mesentery and the broad ligaments was originally retroperitoneal tissue; therefore, a residuum may have been carried into the mesentery along with the blood vessels or the blood vessels of the cell rest may have been carried into the mesentery, thus accounting for the anatomical picture.

Neurofibromatosis offers a condition which must be of interest to any one who concerns himself with the etiology of tumors, especially fibromata. According to Kaufmann, the condition is conceded to be on a congenital basis. There is a distinct pattern in the constitutional manifestations; anomalies in the osseous system and disturbances of intelligence are common and the tendency to form fibromata, myxofibromata, and sarcomata is present. Kaufmann states that the disease usually manifests itself first by the presence of skin pigmentations and skin tumors. Frequently pigmented skin anomalies as well as pale nævi, adenomata of the sebaceous glands of the face, and all types of nævus-like growths are present. Brain lesions often appear in the wake of this pattern and tumors of the nerves as well as tumors of the gastro-intestinal tract may follow. These tumors which may arise on a congenital basis are a part of the clinical picture of neurofibromatosis and are of interest because of the close resemblance to true fibromata. Grossly they are practically identical and microscopically they can at times be differentiated only by special stains; in fact, Kaufmann states that pure fibromata may grow from either the perineural or endoneural connective tissue. Verocay believes that the tumor consists of a structure the result of a multiplication of the cells of Schwann and that it is not connective tissue since it does not stain red by Van Gieson stain; on the contrary it takes a yellow stain.

In 1932, Hausmann and Budd reported a series of 17 cases of massive unattached retroperitoneal tumors of urogenetic origin. In this series there was no case of fibroma but two fibrosarcomata. Our attention was drawn to the fact that they reported 2 cases of retroperitoneal chorio-epitheliomata, both in males. They stress the urogenic fetal rests and conclude from their own experience and from evidence obtained from the literature that almost all tumors which occur in adult urogenital organs may occur free along the course of development of the urogenital apparatus and that these free tumors arise from remnants of the urogenital apparatus is the most logical explanation of their histogenesis.

The theory of Ewing relative to the origin of fibromata in general can be applied to retroperitoneal fibromata. Misplaced islands

of tissue, the cells of which possess the potential to growth, may lead to tumor formation; moreover, specific cells such as epithelial cells may by their presence or due to the products of their metabolism stimulate the connective tissue to localized growth much as an irritation produces fibromata of the mucous membranes. When the process is once activated, the primary cells may become inactive or disappear and the process may continue to the formation of large tumors of a secondary type.

CASES IN THE LITERATURE

Cases of pure retroperitoneal fibroma are extremely rare. In 1901, Goebell in searching through the literature was able to find reference to only 7 cases. Of these several are questionable, as example, the first case which was reported by Beveridge. The original report published in 1870 includes no microscopical examination but it was stated that the growth was suspiciously a neurofibroma. Buschmann's case was a fibromyoma and the one reported by Bruntzel, a fibrolipoma. Moericke's case appeared to be a fibrous tumor but no microscopical examination was included in the report. In one of Joubert's cases no microscopical examination was made. Since 1901, I have been able to find the report of only 4 cases of pure retroperitoneal fibromata. Childe, in 1913, reported the removal of a fibroma with myxomatous areas weighing 34.75 pounds; Graham in 1916 removed a fibroma the size of a large grape-fruit but stated that the tumor was attached to the colon which necessitated a bowel resection. This was most likely a myofibroma of the type described by me in 1928 under the topic of "Leiomyomata of the Intestines." Magoun, in 1919, reported from the Mayo Clinic that during the period from 1907 to 1919 among 73 non-metastatic retroperitoneal tumors, 1 fibroma was encountered. Ogilvie in 1923 reported from the clinic of Rowlands an instance of a tumor 2½ by 4 inches removed from retroperitoneal space. Microscopic examination showed it to be a fibroma with much necrosis. Several suspicious cases in the literature lack microscopic verification.

A relatively large number of benign retroperitoneal tumors of other types are reported in the literature. In 1910, Vegesack in searching the literature found reference to 58 cases of pure lipoma and added one of his own. He found an additional 50 cases of mixed benign tumors. Of this series, 74.2 per cent were in females and 25.8 per cent in males. In 1921, von Wahlendorf tabulated 153 proved cases of benign retroperitoneal tumors; 72 per cent were in females and 28 per cent in males. Of the total number 46 per cent were pure lipomata and 54 per cent mixed tumors. Of the mixed, 20 per cent were fibrolipomata, 10 per cent myxolipomata, 10 per cent fibromyxolipomata, and 14 per cent showed evidence of early sarcomatous changes. In 1932, Bettman and Serby reported the removal of a retroperitoneal lipoma weighing 22.5 pounds and Koch recently removed a very large lipoma. The common tumor is of the mixed type often with myxomatous changes. Ganglioneuromata have been reported and various cysts and teratoma-like tumors are encountered.

SYMPTOMS AND SIGNS

The symptoms produced by the various types of benign retroperitoneal tumors are quite similar. They depend upon the location of the tumor, whether the tumor is large or small, and whether it is growing rapidly. In a large percentage of cases the earliest symptom is a vague sense of weight and distress in the abdomen. The distress may be present for a considerable period of time, extending at times over a period of years, as is illustrated in the case just reported. The distress may bear a relationship to the intake of food, the bowels may be irregular, and the discomfort is often attributed to faulty elimination. Cohn states: "The symptoms caused by a retroperitoneal growth are dependent on the location of the growth. Proximity to the cœliac plexus causes digestive phenomena whereas growths even of larger size in other locations may not cause digestive disturbances." The dyspeptic symptoms present in many cases are often transitory and do not appear to be produced alone by pressure. In the instance reported by Childe in which a tumor weighing 34.75 pounds was removed, he states: "Bilious attacks and constipation formerly complained of disappeared with the growth of the tumor."

Pain sooner or later makes its appearance. It may be produced in a number of ways and be variable in character and location. Pressure of the tumor upon the intestinal tract may produce cramp-like abdominal pains suggestive of incomplete intestinal obstruction. A referred pain may be an early symptom. This pain which is referred to the leg or foot or to the testicle on the affected side is due, probably, to compression of the nerve trunks of the lumbar or sacral plexus. Stratton called attention to this phenomenon in his case in which a very large fibromyxoma with sarcomatous changes was removed. The pain was referred to both the leg and testicle on the affected side. Bruntzel also reported that his patient began having pain in the foot and thigh on the affected side when the tumor began growing rapidly. A type of pain suggestive of obstructive hydronephrosis may be present. In one case reported by Goebell, the decrease of urinary output of the patient was associated with severe pain on the affected side. Increase of urinary output was synchronous with relief or amelioration of the pain. Bladder pain may be present when the tumor lies deep in the pelvis and compresses the bladder.

Œdema of the penis or the extremity or scrotum on the affected side is constantly referred to in the literature. In his report Beveridge stated that the first symptom noted in his case was a swelling of the right leg and thigh. A month later an enlargement of the abdomen was observed. In the case reported by Johnson, the swelling of the scrotum was more marked at night. Goebell, Douglas, and others stress the importance of the unilateral œdema and believe it due to pressure of the tumor upon the vena cava. Cohn believes that a right sided growth readily produces œdema whereas a left sided lesion may not be associated with œdema of the extremities. In my case there was no œdema present during the period of observation nor was there a history of œdema. If the œdema is caused by compression on the vena cava, its absence in my case can be readily explained because of the position of the tumor on the left side with the vena cava and pelvic vessels comparatively unmolested.

Occasionally urinary symptoms are encountered. This symptom is usually present when the tumor lies low in the abdomen or becomes wedged in the pelvis. Stratton's second case quite early in its course presented pain and pressure symptoms referable to the bladder with frequency and burning. As referred to previously, symptoms suggestive of hydronephrosis may be present. Goebell noted in 1 case a variable daily urinary output suggestive of obstruction. It is instructive to note, however, that in most of the cases of benign retroperitoneal tumors even when very large, the urine was normal.

Retroperitoneal masses may be associated with a chylous ascites and chylous pleural effusions as cited by Cohn in his case.

Very commonly benign retroperitoneal tumors possess irregular growth. They may grow slowly for a period of years and then suddenly increase in size very rapidly. This phenomenon does not mean, of necessity, a malignant change. It was present in my case. Bruntzel, Beveridge, and others have called attention to this phenomenon in reporting cases of benign retroperitoneal tumors. No doubt a hæmorrhage into the tumor or types of degeneration may bring about a rather sudden enlargement. The progressive and rapid enlargement of the tumor is associated, in practically every instance, with a decline in the patient's general condition. Weakness, loss of weight, malaise, and an anæmia may supervene. A sallow skin suggestive of a malignant cachexia may be present. In the late stages, the general decline of the patient's health predisposes him to intercurrent infection or fatal nutritional disturbances.

PHYSICAL FINDINGS

The physical findings will vary with the size and location of the tumor. Early when the tumor is small it is easily overlooked, since the symptoms may be referred to a distant part of the body and may in no wise indicate the true nature of the disease. In the majority of cases a tumor will be found lying deeply in the abdomen. It is usually movable, more in the transverse than in the vertical plane of the body. As the tumor increases in size it tends to become fixed. Lipomata are often irregular in

contour and may be soft in consistency. Some may be soft and give to the palpating finger the sense of fluctuation. In several cases reported, a diagnostic puncture had been made in the belief that the tumor was a cyst. No less a master than Billroth was confused by such a case. Not all lipomata are soft, however. The fibroma is usually rather firm and resistant to pressure and is more likely to be smooth as was true in the case just reported. The diaphragm may be pushed upward and immobilized by the tumor when the latter lies high in the abdominal cavity. Displacement of the abdominal viscera is invariably present when the tumor attains large dimensions. The displacement varies with the location of the tumor and especially with the site of origin of the tumor. The intestines, as a rule, are pushed forward and downward and then to the opposite side as seen in my case. If the tumor takes its origin above and behind the kidney, this organ will be pushed downward or to the opposite side. Mathews reported a case giving no symptoms except an enlargement of the abdomen. The spleen was displaced upward and the kidney was pushed forward so that it lay in contact with the anterior abdominal wall. In the case reported by Baxter, a tumor on the right side displaced the right kidney to the left of the spine, the kidney being rotated on its axis so that the pelvis of the kidney faced to the right. In this instance the kidney was completely embedded in the tumor. Opaque material in the gastro-intestinal tract and the genito-urinary system with roentgenological study gives invaluable information in localizing the tumor. It should be stressed that in every instance of retroperitoneal tumor a thorough study should be made of both kidneys since it happens at times that the kidney on the affected side may be involved in the tumor necessitating its removal.

When the tumor reaches a very large size so as to fill a good share of the abdominal cavity, its origin or point of primary attachment cannot be determined. In my case the tumor occupied almost the entire left side of the abdominal cavity and extended to right side. It was assumed that it took its origin in the region of the upper pole of the left kidney since the left kidney was carried down to the pelvic inlet. Since the kidney function on the affected side was normal it was assumed that the tumor did not involve the kidney substance. Such large tumors are difficult to outline or define. They become fixed due to lack of space and impingement against the spine, abdominal wall, and the diaphragm.

DIAGNOSIS

The diagnosis of retroperitoneal tumors is difficult in many instances. When the tumor is small, the posterior position with rather free movability is suggestive, yet intraperitoneal tumors may possess this characteristic. The majority of errors involve ovarian cysts, tumors of the kidney, retroperitoneal sarcoma, and splenic enlargements. The kidney can, in most instances, be eliminated by a careful functional study with intravenous or retrograde pyelography; moreover, most kidney tumors sooner or later present pathological urinary findings. Splenic tumors are more difficult to differentiate. In my case a diagnosis of splenomegaly had been made prior to admission to the hospital. A careful examination of the physical characteristics of the tumor and blood studies should, in the majority of instances, make the differentiation. A splenic tumor will not displace the left kidney. Large ovarian cysts or tumors and pedunculated uterine fibroids may be confused with retroperitoneal tumors. These tumors are more movable than retroperitoneal tumors which extend into the pelvis, and it is often possible to ascertain a point of attachment to the pelvic adnexa.

Such tumors as mesenteric cysts, tumors of the omentum, are difficult to differentiate from retroperitoneal tumors. A carefully conducted roentgenological study of the gastro-intestinal tract will not reveal the characteristic displacement of the intra-abdominal organs, neither will the kidneys be displaced. Cysts of the pancreas are more fixed and have a tendency to protrude anteriorly.

Retroperitoneal sarcoma is the usual diagnosis made in the presence of a benign tumor. Early in its course this type of tumor is often encapsulated and movable. It grows rapidly but no more so than does a benign tumor. The one referred to early in this paper was present

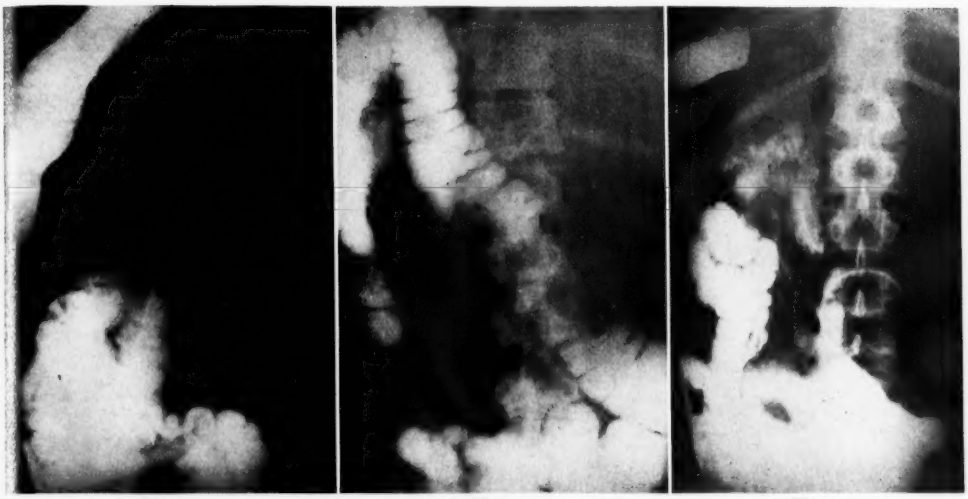

Fig. 1. Fig. 2. Fig. 3.

Fig. 1. Roentgenogram showing the displacement of the stomach to the right and anteriorly and the small bowel downward and to the right.

Fig. 2. Roentgenogram showing the displacement of the colon. The splenic flexure is below the iliac crest and the transverse colon courses to the right and upward.

Fig. 3. Roentgenogram showing a small 5 hour gastric residue, also the displacement of the small bowel to the right and downward. This film also shows an opaque ureteral catheter in the left ureter.

in a well nourished individual; there had been no loss in weight and subjective symptoms were practically absent. These factors led me to make a diagnosis of a benign tumor.

Buettner stressed three points in the diagnosis of benign retroperitoneal tumors: (1) the exact location where the tumor was first noticed; (2) whether there is a connection with the genital organs; (3) the topographic displacement of the intestines.

TREATMENT

A study of the literature indicates that the diagnosis of benign retroperitoneal tumor is rarely made; however, with careful study, I believe that in a considerable number of cases the tumor may be recognized or at least a strong suspicion may be aroused. New methods of study and an understanding of the condition will lead to more correct diagnoses. It is my firm belief that all cases of abdominal tumors should be explored in spite of size, location, or preconceived ideas relative to the nature of the tumor. A comparatively small tumor may produce symptoms which strongly suggest a malignant process. However, in spite of the suggestion, an attempt should be made to determine definitely the nature of the process and an equally intelligent attempt should be made to remove it if advisable. The very large benign tumors carry a high mortality rate when operated upon yet, in many instances, removal has been carried out with little operative reaction.

In my case spinal anæsthesia was used because of the relatively good condition of the patient and with the knowledge that relaxation of the abdominal wall would be an invaluable asset. The type of incision will depend upon the size and location of the tumor. In the presence of a large tumor, the transverse incision with an accessory vertical incision gives good access to the retroperitoneal space. The counter incision may be carried upward or downward or both as needed. Suturing the muscles to their fascia prevents retraction of the muscle fibers and materially assists when the closure is done. In my case the peritoneal cavity was deliberately opened in order to determine the anatomical situs of the tumor, since a splenic tumor was suspected before the final diagnosis was made.

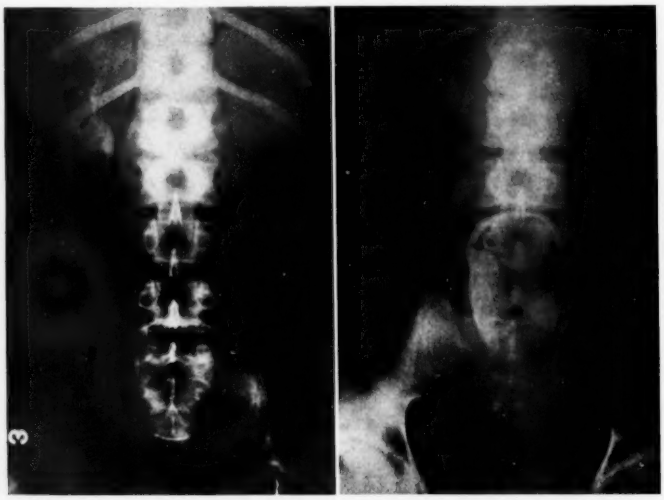

Fig. 4, left. Roentgenogram taken after an intravenous injection of skiodan. The pelvis of the right kidney appears normal, the left is not visualized.

Fig. 5. Roentgenogram showing a catheter in the left ureter with an injection of the pelvis of the displaced left kidney. The pelvis lies to the right of the posterior spinous processes, the center overlying the intravertebral disc between the fourth and fifth lumbar vertebræ.

In most instances the tumor is well encapsulated. Therefore if the line of cleavage is found the enucleation is easy. However, gentle separation must be insisted upon because blood vessels, usually veins, of great size, may enter the tumor and should such large vessels be torn in an inaccessible region such as behind or at the upper pole, fatal hæmorrhage may ensue. The case reported by Buschmann which was operated upon by Billroth seemed cystic, so a trochar was inserted to evacuate the fluid. Profuse bleeding followed and it was later discovered that the trochar punctured one of the large veins which coursed over and through the tumor. Some of the veins were as large as the collapsed small bowel. In Beveridge's case the right iliac vein was completely involved. As was mentioned earlier in this paper, the kidneys should always be studied relative to their individual function since at times it becomes necessary to remove one when it is involved in

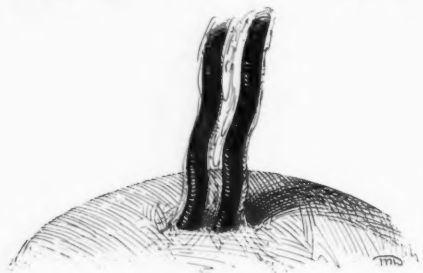

Fig. 6. Drawing illustrating the manner in which the veins made their exit from the tumor.

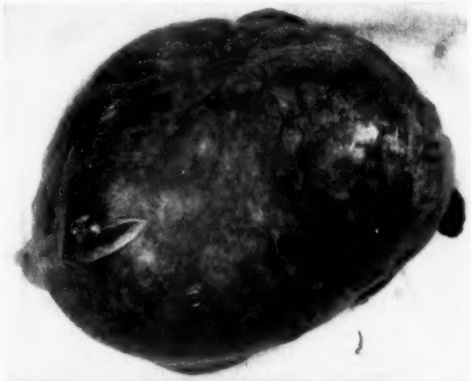

Fig. 7. Photograph of the tumor, a pure retroperitoneal fibroma weighing 16.5 pounds. It measured 32 centimeters in length and 68 centimeters in circumference.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 8. Photomicrograph showing the long spindle shaped cells characteristic of a fibroma. ×120.

Fig. 9. Photomicrograph showing few nuclei and the thick wavy fibrillæ which stained deep red with Van Gieson's and dark blue with Mallory's aniline blue stains. ×310.

Fig. 10. Photomicrograph of an area of the tumor where the cells are more numerous and the intercellular substance less abundant. ×310.

the tumor. In Bruntzel's case the tumor was attached to the left kidney necessitating its removal. Childe was able to strip the tumor from the kidney, to the capsule of which it was attached. Koch recently had to remove the kidney because it was involved in a large lipoma.

Occasionally the tumor has a pedicle of some size which requires section. This pedicle should be brought into view, clamped, and cut. Blunt, blind tearing may cause damage to important structures or lead to profuse, often fatal, bleeding. Great care should be exercised in separating the posterior peritoneum from the tumor for fear of injuring the blood supply or continuity of the bowel. In my case there was a loose areolar connection between the tumor and the posterior peritoneum, the thin filmy tissue containing two very large veins. This attachment was not visualized before displacement of the tumor, yet it could be felt during the process of enucleation. This incidence again emphasizes the necessity for care in the process of enucleation of the tumor.

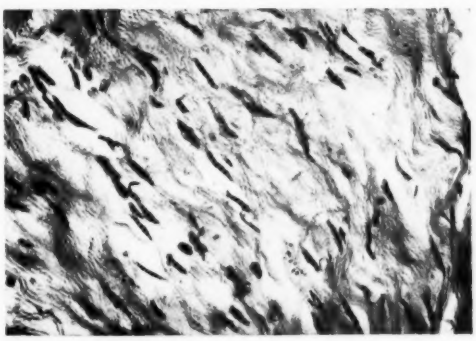

Fig. 11. Photomicrograph showing the cells to be separated by spaces filled with thin, homogeneous, very palely staining material (œdema). ×320.

All bleeding or oozing points should be carefully ligated to prevent the formation of a hæmatoma. In most instances with the trauma due to the removal of the tumor there is a considerable fall in the blood pressure. The reactionary rise may take place soon after the conclusion of the operation and extensive bleeding may ensue. In my case it was interesting to note the tendency of the organs to assume their normal position after the removal of the tumor. The left kidney which was at the inlet of the pelvis immediately moved upward and to the left; the bowel pushed the posterior peritoneum to the left so that the large space was apparently com-

pletely obliterated; in fact, some difficulty was encountered in closing the abdominal incision. Nevertheless, I believe that drainage is desirable. Complete hæmostasis cannot be secured and a retroperitoneal hæmatoma is likely to become infected. The encapsulated empyema complicatimg my case has not been explained nor could the perforation of the diaphragm be satisfactorily explained.

The prognosis in benign retroperitoneal tumors must be a guarded one. Many authors stress the frequency of secondary malignant manifestations. This applies especially to large dissecting lipomata, in which parts of the tumor are not removed, and to mixed tumors such as lipomata and fibromata with myxomatous degeneration. In his work on the peritoneum, Hertzler states: "Lipomatous tissue is often intermingled with myxoid, and the latter is always closely related to sarcoma. It is the tendency to admixture that removes them from the usual class of histoid tumors." Inadequate examination of large tumors may lead to an erroneous diagnosis relative to the presence of malignant changes. In a series of 113 cases of benign retroperitoneal tumors operated upon, von Wahlendorf reported 15 recurrences and 60 (54 per cent) cures.

The operative mortality depends to a considerable degree on when the operation is done in relation to the size of the tumor. The comparatively small retroperitoneal tumor can be removed with little danger as to life; however, very large tumors are difficult to remove and, according to Vegesack, the operative mortality approaches 38 per cent. In the 113 operations reviewed by von Wahlendorf there were 29 (25 per cent) deaths during or shortly after operation. The pre-operative preparation of the patient, the judgment exercised in the selection of the anæsthesia, the nature and size of the tumor, and the surgeon's ability are important factors which control the mortality rate.

BIBLIOGRAPHY

1. Albrecht. Quoted by Schwalbe. Die Morphologie der Missbildungen des Menschen und der Tiere. Part 3. Jena: G. Fischer, 1911.
2. Baxter, S. H. Retroperitoneal tumor. Minnesota Med., 1924, vii, 42–48.
3. Bettman, R. B., and Serby, J. Retroperitoneal lipoma, etc. Arch Surg., 1932, xxiv, 300.
4. Beveridge, R. Case of large fibrous tumor of the abdomen. Med. Times & Gaz., 1870, i, 607–8.
5. Bonnet, R. Zur Aetiologie der Embryome. Monatschrf. f. Geburtsh. u. Gynaek, 1901, xiii, 149–176.
6. Bruntzel, R. Extirpation der linken Niere wegen eines kolassalen 37¼ pf. schweren Fibroms der Nierenkapsel. Berl. klin. Wchnschr., 1882, 745–748.
7. Buschmann, Baron. Extirpation eines sehr grossen retroperitonealen Fibroms und der damit verwachsenen in Becken gelegenen linken Niere. Wien. med. Wchnschr., 1880, xxviii, 800–801.
8. Buettner. Cited by Vegesack. V. Ueber retroperitoneale lipoma. Beitr. z. klin. Chir., 1910, lxix, 578–596.
9. Childe, C. P. A case of retroperitoneal fibroma weighing 34¾ pounds successfully removed. Brit. M. J., 1913, ii, 1090.
10. Cohn, I. Retroperitoneal tumors; a report of cases. Arch. Surg., 1931, xxiii, 655.
11. Douglas, R. A study of retroperitoneal neoplasms. J. Am. M. Ass., 1898, xxx, 705–8.
12. Ewing, James. Neoplastic Diseases. Philadelphia: W. B. Saunders Co., 1919.
13. Goebell, R. Zur Kenntniss der lateral-retroperitonealen Tumoren. Deutsche Ztschr. f. Chir., 1901, lxi, 1–92.
14. Graham, H. F. Retroperitoneal fibroma; resection of gut. Long Island M. J., 1916, x, 75–77.
15. Hausmann, G. H., and Budd, J. W. Massive unattached retroperitoneal tumors. J. Am. M. Ass., 1932, xcviii, 6–10.
16. Hertzler, A. E. The Peritoneum. Vol. ii. St. Louis: C. V. Mosby Co., 1919.
17. Joubert, H. Fibrous tumors of the pelvis simulating ovarian tumors. Brit. Gynæc. J., 1890, vi, 362–368.
18. Kaufmann, E. Lehrbuch der speziellen pathologischen Anatomie. Part 2. 1922.
19. Kuester. Die Chirurg. Krankheiten der Nieren. 1st half. Deutsche Chirurgie.
20. Magoun, J. A. H., Jr. Retroperitoneal tumors. Med. Clin. N. America, 1919, iii, 689–703.
21. Marchand. Cited by Schwalbe.
22. Mathews, F. S. Retroperitoneal myxolipofibroma. Ann. Surg., 1918, lxvii, 246.
23. Moericke. Casuistische Mittheilungen. Ztschr. Geburtsh. u. Gynaek, 1882, vii, 418–429.
24. Ogilvie, W. H. Retroperitoneal fibroma arising from ant. common ligament. Lancet, 1923, cciv, 228.
25. Schwalbe, Ernst. Die Morphologie der Missbildungen des Menschen und der Tiere. Part 3. Jena: G. Fischer, 1911.
26. Stratton, F. A. Retroperitoneal tumors; report of two cases. Wisconsin M.J., 1923–1924, xxii, 260–263.
27. Vegesack, H. V. Ueber retroperitoneale Lipoma. Beitr. z. klin. Chir., 1910, lxix, 578–596.
28. Verocay. Quoted by Kaufmann, E. Lehrbuch der speziellen pathologischen Anatomie. Part 2, 1922.
29. Von Wahlendorf, A. R. L. Ueber retroperitoneale Lipome. Arch. f. klin Chir., 1921, cxv, 751–768.
30. Wiesel, Joseph. Accessorische Nebennieren im Bereiche des Nebenhodens. Wien. klin Wchnschr., 1898, xi, 443–444.

SOME REMARKS ON THE OPERATIVE PROCEDURES FOR APPENDICITIS[1]

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THE widespread interest in the mortality of appendicitis has prompted us to make a careful study of over 3000 cases[2] which have been operated upon in the Cincinnati General Hospital. In accord with the published reports of others this study revealed that delay in operating and the use of purgatives were the principal factors in the unnecessary sacrificing of lives. Yet there was a certain other factor having to do with the operative procedure which seemed to us to be significant. A short discussion of this factor together with a description of two points of technique which appear to make the operation of appendectomy safer and simpler is dedicated along with the author's admiration and affection to Dr. Allen Kanavel.

From 1915 to 1922, operations for acute appendicitis in the Cincinnati General Hospital were performed through a right rectus incision. During this time 409 cases of acute appendicitis were operated upon and the mortality rate was 9.8 per cent.

Early in 1922 the McBurney incision was adopted for acute appendicitis and has been exclusively used since then. Sixteen hundred and twenty-six cases have been operated upon with a mortality rate of 5.2 per cent. The significance of this contrast is slightly altered by the fact that the percentage of cases with abscess and peritonitis fell from 51.3 per cent in the first series to 41.6 per cent in the second. The average lapse of time between onset of symptoms and operation and the use of purgatives are, so far as we can judge from the histories, about the same in both series.

Does not the type of incision play a definite rôle in the mortality rate of acute appendicitis? When one studies the tables of the United States Standard Mortality Statistics dealing with appendicitis and the excellent reviews by Bowers it seems apparent that the death rate is lower in those cities where the McBurney incision is most widely used.

[2] A complete analysis of this study will soon be published.

The advantages of the McBurney incision are too well known to be discussed. The most important of them appear to be: (1) There is less soiling of the general peritoneal cavity; (2) there is less necessity for handling the intestines, for usually it is necessary to touch only the cæcum and appendix; (3) with the modern means of suction the traumatizing effects of gauze packs can be eliminated; (4) drains can be placed in contact with the parietal peritoneum where they soon become, in fact, extra-abdominal and are not surrounded by intestines; (5) wound complications are less; (6) convalescence is shorter; and (7) the healed wound is less disabling.

Does not chagrin play an unwarranted rôle in the opposition to the McBurney incision? The diagnosis of acute appendicitis may of course be wrong. When it is and has been determined through a McBurney incision it may be the wise procedure to close the wound and let the patient alone as, for example, in acute salpingitis. Usually the sites of other conditions *simulating acute appendicitis* and requiring immediate operation can be determined through a McBurney incision. Another incision can then be made to suit the condition. Failure to determine the acute trouble through a McBurney incision can always be followed by an exploratory incision with little or no damage resulting from the first incision, which frequently can be used advantageously as a drainage point.

The author and the members of our surgical department have long ceased to have feeling of embarrassment after making a McBurney incision for a mistaken diagnosis of *acute appendicitis*. Often, as stated, no other incision has to be made. Our experience has been that an explanation before operation of the advantages and disadvantages of the McBurney incision and a frank admission of the operator's findings not only may save lives, but, instead of feeling of chagrin, secure for the surgeon the patient's admiration for his honesty.

[1] From the Department of Surgery of the College of Medicine of the University of Cincinnati and the Cincinnati General Hospital.

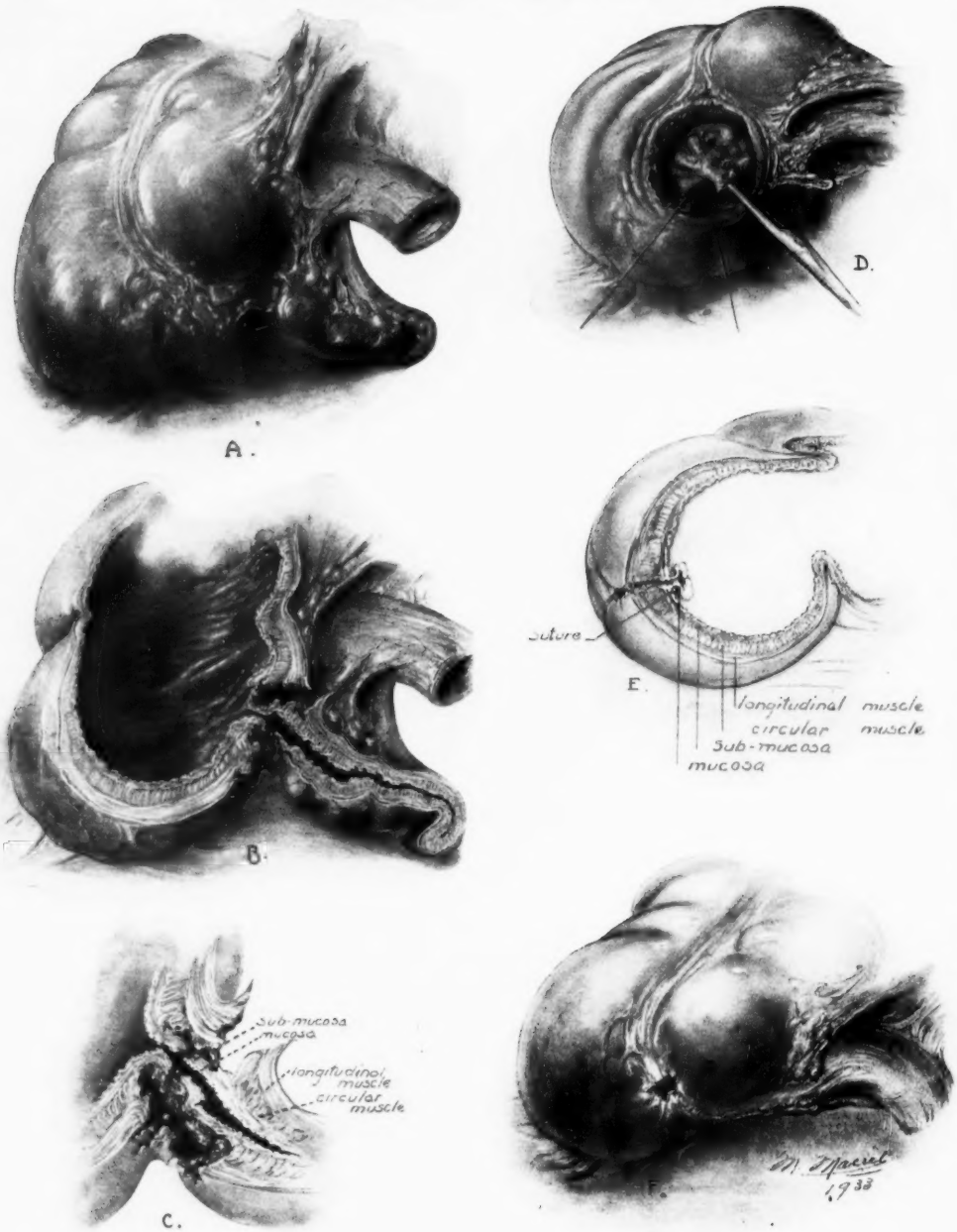

Fig. 1. A, Inflammation, œdema, and induration of the cæcum associated with gangrene or rupture of the appendix near its base. B and C, Cross sections, showing the effects of a gangrenous process at the base of the appendix. Note the œdema and thickening of the muscular coats of the cæcum. D, Thickened muscular coats reflected and a purse string suture placed in the submucosa above the areas o necrosis. E and F, Stump of submucosa inverted by purse string suture and the muscular coats rolled back into plac without the use of any sutures.

There is more argument against the McBurney incision when the problem is one of differentiating between operating for chronic appendicitis and some other intra-abdominal condition. It would be futile to argue this question. I must content myself with a statement of our policy which is either not to operate at all or to remove first the appendix through a McBurney incision and then wait to see if the patient's symptoms disappear. The patient's co-operation in such a program is usually enthusiastic, for he often knows from friends the painful disabling consequences of a long exploratory incision.

What has been written thus far is offered in support of the belief that the surgical technique of appendectomy is playing a more important rôle in the mortality statistics of acute appendicitis in this country than is generally appreciated. Campaigns in favor of immediate operation for acute appendicitis and against the use of purgatives and anodynes are undoubtedly the major avenues toward a reduction of the disgracefully high death rate from appendicitis in the United States. Yet, with no appreciable reduction in the elapsed interval between the onset of symptoms and operation or in the use of purgatives or anodynes prior to surgical treatment the death rate for all forms of acute appendicitis (unruptured and ruptured; with abscess and with peritonitis) treated in the Cincinnati General Hospital has been reduced by 50.3 per cent since the routine of a rectus incision was abruptly and completely changed to that of a McBurney incision.

This paper was originally conceived with the idea of drawing attention to two points of technique which we have found especially valuable in the actual removal of certain types of appendices. For them the author claims no originality, for he is well aware that they are employed by many surgeons throughout the country. Yet from actual observations and conversations he is convinced that there are many others who do not use them and who might find them as useful as we have.

A. *When the appendix is gangrenous or ruptured at or near its attachment to the cæcum and the wall of the cæcum about is thickened, œdematous, and often indurated.* In such cases

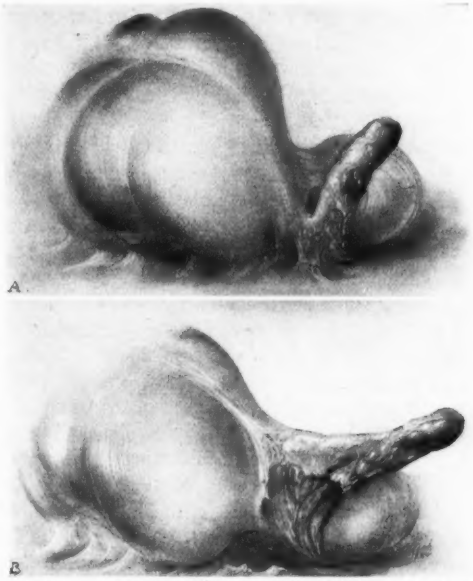

Fig. 2. A, Represents the appendix held down by a band of adhesions or a short stalk of peritoneum. B, After division of them the appendix is readily delivered and its mesentery easily ligated.

a fæcal fistula or a leakage of intestinal contents through the stump is liable to occur, for the closure of the hole in the cæcum is at best insecure. Many surgeons realizing the futility of trying to invert the stump of the appendix simply ligate it as best they can and place drains to take care of the leakage which is likely to occur. Others frequently attempt to invert the stump of the appendix and its surrounding gangrenous gut by means of pursestring or mattress sutures. When successful the surgeon is unhappy because of the force with which it is necessary to tie the sutures, and very frequently because of the tension anæmia about them. Not infrequently such sutures cut through the thickened and œdematous musculature of the gut.

For the procedure proposed for, and now regularly used in, such cases the author finds the basis of his rationale in the fundamental researches of Mall and Halsted who drew attention to the importance of engaging with the sutures the tough fibrous layer of the submucosa whenever repairing defects of the gut wall or performing intestinal anastomoses.

What student of Halsted can fail to remember his demonstration of the ease with which a small straight needle engaging only the musculature of the gut could be torn out, and the equal ease with which the needle could be broken, without tearing through, if it caught only a small portion of the submucosa?

In the condition under consideration this tough fibrous submucosa does not become swollen and œdematous, and from it the thickened and inflamed muscular layers may be easily separated. When this is done, the defect in the cæcum may be easily closed, and without tension, by placing mattress or purse-string sutures only in the submucosa. The reflected and inflamed muscular coats can then be rolled back into place without the necessity of ever taking any sutures through them.

With this method (Fig. 1) of dealing with the stump of the appendix in this particular form of appendicitis, it is necessary to drain fewer cases and the occurrence of fæcal fistulæ has been thus far completely eliminated.

B. *When the appendix is not easily delivered into the wound.* The difficulty of delivering the appendix may of course be due to many causes, such as retrocæcal or abnormal positions. Very frequently the tip of the appendix and its base will come up readily into the wound while some part of the intervening portion will be held down close to the posterior peritoneum giving a definite impression that the appendix is badly kinked. The cause of this real or apparent binding of the appendix is most frequently due to a peritoneal stalk which is much shorter than the actual mesentery of the appendix. In many instances there are actual adhesions which may, in addition to the short peritoneal stalk, make it difficult to deliver the mesial portion of the appendix. A simple division with a sharp knife of the peritoneum and adhesions along the outer side of the appendix will, in most every instance, uncover a mesentery which is sufficiently long to allow the entire appendix to be delivered out of the wound before the clamping and dividing of any portion of the mesentery. The operation then becomes easy and one ligature will usually suffice for the ligation of all the vessels in the mesentery. The ease of this procedure is most striking when compared with the difficulty of ligating or clamping the mesentery of the appendix in the depths of the wound, which is not necessary if one first divides the peritoneum and adhesions just lateral to the appendix and carefully frees its mesentery.

Not infrequently when one is pulling on the end of the appendix, the short lateral peritoneum will give the operator the impression that it is a narrow band of adhesions when in reality, without traction on the appendix, it becomes smooth, flattened normal peritoneum.

With careful sharp dissection, it is most unusual to divide any vessels in either the peritoneum or adhesions which require ligation. Usually in kinked or bound-down appendices, the mesentery can be completely freed and the appendix brought through the McBurney incision without the necessity of ligating any vessels (Fig. 2). Then, when the mesentery of the appendix is divided, the raw surface is easily covered by suturing the peritoneal defect.

SUMMARY

1. In a study of 2,035 cases of acute appendicitis operated upon at the Cincinnati General Hospital there has been a decrease of 50.3 per cent in the mortality rate since the operative procedure was changed from a rectus to a McBurney incision.

2. The fear of a mistaken diagnosis of acute appendicitis is probably playing an unwarranted rôle in making surgeons adhere to a rectus or pararectus incision. When the diagnosis is wrong, it is our experience that the McBurney incision far more frequently serves a useful purpose than a harmful one. The disabilities and dangers of a long exploratory incision should be borne in mind.

3. A method of dealing with the stump of the appendix in cases of acute appendicitis in which the cæcum is inflamed, indurated, and thickened, is described and illustrated.

4. The importance of freeing the mesentery of the appendix before ligating it is discussed.

REFERENCES

1. Bower, John O. Acute appendicitis in Philadelphia. J. Am. M. Ass., 1934, cii, 813–816.
2. Idem. Mortality of acute appendicitis. J. Am. M. Ass., 1932, xcix, 1765–1767.
3. Idem. Acute appendicitis. J. Am. M. Ass., 1931, xcvi.
4. Halsted, W. S. Am. J. M. Sc., 1887, xciv, 436–461.

THE RETURN OF SENSATION TO TRANSPLANTED SKIN[1]

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THE study of the return of sensation to transplanted skin offers an opportunity to add to our knowledge of the controversial question of sensation. There are several questions, the answers to which might throw some additional light upon a difficult subject. Sensibility of the skin cannot be investigated successfully in the experimental laboratory, but neither can it be investigated clinically by crude and unorthodox methods of sensory stimulation. Although abundant clinical opportunities have presented themselves for the study of the return of cutaneous sensibility in skin grafts and pedicle flap operations, very few have been reported.

Naturally the order and pattern of the return of sensation is the first question which arises. Does the response to pin prick return before that to cotton wool touch and temperature, or does sensation to these stimuli return simultaneously? Does the pattern of sensory return advance from the borders of the transplanted skin; does it advance eccentrically or in patches? What are the characteristics of the return of sensation in a skin transplant which has been placed over an area supplied by two peripheral nerves, one of which has been severed? If a skin transplant is placed over an area supplied by two peripheral nerves, and sensation has returned to the transplant, if one nerve is severed will sensation disappear from all of the area supplied by that nerve? Can sensory return be demonstrated in a skin transplant placed over an area the nerve supply of which has been severed, when there has been no return of sensation in the isolated supply of that nerve? Does sensation return as the result of overlap as is the case following peripheral nerve injuries? Do nerve fibers from adjacent uninjured skin grow into protoplasmic bands in the transplanted skin? What effect does the thickness of the transplanted skin have upon the rate of recovery of sensation? Can nerve fibers be shown microscopically in the transplanted skin after sensation has returned?

Quite logically and naturally we immediately become involved in the various theories and fewer facts which have been established regarding sensory recovery following peripheral nerve lesions. From a clinical standpoint our knowledge of the sensory changes which are present during recovery of function in a peripheral nerve is contradictory and in many instances fragmentary.

It has been noted by many observers that the total sensory loss in the skin following complete division of a peripheral nerve is smaller than what we know to be the anatomic distribution of that nerve. This phenomenon has been explained by the supposition that (1) nerve fibers grow into the insensitive area from adjacent uninjured parts; (2) many cutaneous areas receive a sensory supply from different nerves; and (3) that collateral innervation may be easily established by an accessory branch of the injured nerve and an adjacent uninjured nerve.

In 1905, Henry Head (5), had the superficial radial and lateral antebrachial cutaneous nerves of his left arm cut and sutured. In collaboration with Rivers and Sherren he observed the characteristics of the return of sensation in the affected area. As a result of his studies Head came to the conclusion that the skin was supplied by two distinct groups of nerve fibers. One group of fibers transmit protopathic sensibility and are capable of responding to painful cutaneous stimuli and to the extremes of heat and cold. The second group of fibers mediate epicritic sensibility, by which is gained the power of cutaneous localization, discrimination of two points and the finer grades of temperature. Head found that heat and cold returned simultaneously with pin prick stimulation but epicritic sensation returned at a definitely later date. Head's theory received general approval but the later more careful work of Trotter and Davies (11), Boring (2) and Pollock (8), all of whom pointed out the deficiencies of Head's work, remains unrecognized generally. Trot-

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ter and Davies stated that tactile, thermal, and pain sensibility appear at the same time at the most proximal part of the affected area and believe that a gradual substitution characterizes the process of regeneration. Boring's conclusions were essentially those of Trotter and Davies except that he believed that the sensation of warmth and cold passes through a stage of hyperæsthesia. Pollock emphasized the error of interpreting nerve overlap as evidence of regeneration. He has determined the residual sensibility of the commonly injured peripheral nerves and states that the return of sensibility to prick pain which occurs before the return of sensibility to touch is due to the assumption of function by adjacent nerves. In other words, regeneration can be said to have occurred only when "that portion of the area representing the anatomic sensory supply of an injured nerve which is removed from the influence of overlap becomes sensitive." In this area of isolated supply, pain and tactile sensibility return simultaneously.

In an effort to obviate some of the criticisms of nerve overlap, Sharpey-Schafer (9) made a study of the return of sensation in his own fifth finger and pointed out two facts which have some bearing upon this problem. In the area of sensory loss following crushing of the digital nerve on the ulnar side of his finger, pain returned first followed by heat and cold and, lastly, touch. On the other side of the finger the digital nerve was cut but not resutured. There an unpleasant hyperalgesia occurred and normal touch and temperature sensibility did not return. It should be remembered that crushing produces an indefinite and inaccurate lesion both as to the degree and extent of the lesion.

A most interesting contribution which has a direct relation to this problem has been made by Boeke and Heringa (1). The latter accidentally severed his ulnar artery, several tendons, the dorsal ramus, and the superficial and deep branches of the ulnar nerve at the wrist. Tendon and nerve sutures were performed immediately and the wound healed without any signs of infection. Nine months later, the affected area showed protopathic sensibility. A piece of skin with the underlying subcutaneous tissue was removed from the center of this area and examined for nerve fibers and their endings. Microscopic examination showed that the nerve in both the superficial and deeper layers of the skin showed protoplasmic bands filled with neurofibrillæ. Myelin sheaths were not found but regeneration was noted in the end organs of Ruffini, in some of Meissner's tactile corpuscles and in the nerves supplying the hairs. Consequently, these investigators concluded that protopathic sensibility was due to stimulation of incompletely regenerated sensory organs, and that only when this regeneration was complete did epicritic sensibility appear. It will be noted later, when the records of the examinations of the clinical material are given, that they lend support to this conception of sensory regeneration.

Although there have been many opportunities for the clinical examination of the recovery of sensation in skin transplants, the reports in the literature have been scanty. In 1899, Stransky (10) reported the early return of light touch sensibility in a full thickness skin graft, but after 10 days the entire graft melted away. Stransky's results on the whole are of little value since they were based upon an insufficient amount of evidence. Dubreuilh and Noel (4) examined 11 cases of Wolfe grafts and found that superficial sensibility returned within a year. Williams (12) examined a Thiersch graft which had been applied over the base of a varicose ulcer 30 years previously. He found that pain, temperature, and deep pressure sensibility were slightly diminished but there was a greater loss of tactile sensation. J. S. Davis and Traut (3) have stated that sensation begins at the periphery in all types of skin grafts within 4 or 5 weeks and that tactile sensation is restored first, followed by pain and temperature sensation. Kredel and Evans (7) in a recent and by far the most complete report, concluded that in pedicle flaps, pain, touch, and temperature sensibility return independently and in that order; that in pedicle flaps sensation begins about the periphery and progresses distally and from the sides; that there is no relation between the course of the original neurilemmal sheaths of a skin flap and the ingrowth of new nerve

fibers; and finally, that recovery of sensation is more rapid and complete in pedicle than in Wolfe, Reverdin, or Thiersch grafts.

Finally, some aid may be found in the experimental work which has been reported upon the regeneration of sensory nerve endings. Kadanoff (6) transplanted skin from the sole to the snout in guinea pigs. He found that the new nerve fibers, more numerous than was normal for the foot, frequently followed the old paths, or the blood vessels. He never found regenerating Pacinian corpuscles, nor on the other hand did he ever find degenerative changes in the sensory endings immediately after transplantation.

CLINICAL MATERIAL[1]

Our examinations have been made upon a group of pedicle, free full thickness, and Thiersch skin grafts and have been carried over the period of years from 1920 to the present time. The majority of the pedicle flaps were transferred from the thighs, buttocks, and abdomen to repair deforming defects in the hands produced by neglected and ill-treated infections, and burns. The transplants were made by delayed transfers to insure an adequate vascular supply. Consequently, all of the original nerve supply had been divided completely. A few of the early pedicle and full thickness grafts included more of the subcutaneous tissue than is now the accepted practice.

Methods of examination. Pin prick stimulation was effected by a simple algesiometer which consisted of a large headed pin in the barrel of a glass syringe, the point being allowed to extend through the tip and to replace the plunger. The weight of the plunger determines the degree of pressure when the pin is allowed to prick the skin, with the syringe held by the barrel. By so using a stimulus of known degree, the area of sensory loss may be compared accurately from time to time.

Tactile sensibility was tested for by a wisp of cotton after all of the hairs on the skin had been shaved. Two point discrimination sense was not used uniformly in all of the examinations.

[1] These studies were made upon the patients of Drs. Kanavel, Koch, and Mason at Passavant Memorial and Wesley Memorial Hospitals.

Test tubes containing warm and cold water are relatively inaccurate for testing temperature sensibility and are subject to the danger of stimulating pressure sense. Low degrees of temperature only were tested and for this purpose a pledget of cotton twisted to a point and moistened in ether was used as the stimulus.

In the accompanying charts of sensory recovery the black dots represent return of pin prick sensation; black lines, return of touch; x, painful response to pinprick stimuli; circles, return of cold sensation; s, diminished sensation; solid black, loss of all types of sensation.

CASE 1. J. G. In 1917 a large pedicle transplant (13 by 8 centimeters) was transferred from the abdomen to the dorsolateral surface of the forearm to cover a defect produced by an osteomyelitis of the bones of the forearm. The median and ulnar nerves were intact but the superficial ramus of the radial had been destroyed. In 1920 there was a loss of pain sensation in the center of the transplant and the loss of tactile sensation was larger. The return of sensibility was evidently progressing from the edges. The patient was not examined again until 1923. Pin prick was felt everywhere over the flap and almost in the center there was an area of protopathic response. Here touch was not recognized (Fig. 1).

CASE 2. W. McG. This patient had received a gunshot wound of the left hand in 1917. In July of 1920 a pedicle flap was transferred from the abdomen to the dorsum of the hand. The median nerve had been divided by the injury and was sutured in October of 1920. There was loss of pin prick and touch sensibility limited to the volar and dorsal surfaces of the index finger and to a small area over the dorsal surface of the hand. The sensory overlap in this case had therefore been very extensive. The transplant measured 8 by 5 centimeters. The patient left the city and was not examined until January of 1929. There was a loss of tactile sensation in a small area at the distal border of the transplant but elsewhere sensation was normal. The volar and dorsal surfaces of the index finger showed a protopathic response to pin prick but no return of tactile sensation.

CASE 3. C. N. When one year old this patient's right index finger was burned severely by an electric bulb. A pedicle transplant was transferred from the buttocks in April of 1921. Ten years later the transplant showed normal sensation to all stimuli (Fig. 2).

CASE 4. W. R. When 2 years of age the patient fell into a grate fire and severely burned his right hand. Six years later (1921) the scar tissue was dissected from the palm of the very badly deformed hand. A pedicle transplant was transferred from the buttocks to cover the palmar defect. On February 8, 1923, the patient recognized pin prick over the entire transplant. The response was very definitely protopathic in character and was accompanied by a

Fig. 1. Case 1.

Fig. 2. Case 3.

Fig. 3. Case 6.

Fig. 4. Case 7.

withdrawal reflex. Touch was not recognized. On January 10, 1927, this protopathic response to pin prick stimuli had disappeared completely. Tactile and cold stimuli were recognized everywhere over the transplant.

CASE 5. A. N. When 6 months of age this patient suffered a severe burn on the dorsum of the right hand. A marked deforming contracture resulted. The scar tissue was dissected away and a pedicle transplant was transferred from the abdomen. Six years later (1928) the transplant had grown in proportion to the rest of the hand. Sensation to pin prick and touch was present over the entire flap but the response to pin prick was definitely hyperalgesic.

CASE 6. J. C. The patient received a gunshot injury of the right forearm in 1922. The median nerve was destroyed for a distance of 3 inches above the wrist so that an end-to-end suture was impossible. A pedicle transplant was transferred from the thigh in October of 1923. In January of 1927 there was a small area of normal sensation to pin prick and tactile stimulation in the proximal portion of the transplant. On the radial side of the flap there was protopathic response to pin prick and tactile sensibility was greatly diminished. On the ulnar side of the transplant pin prick and tactile sensibility were present but diminished (Fig. 3).

CASE 7. W. M. The patient received a gunshot wound through the palm of the hand in January of 1924. There was a large loss of tissue on the dorsum of the hand between the metacarpal of the thumb and index finger. A pedicle transplant was transferred to this area from the abdomen on July 1, 1924. At this time there was a loss of pin prick, touch, and temperature stimulation over the entire volar surfaces of the index and middle fingers and on the dorsal surfaces of the distal two phalanges. On September 30, 1924, there was no return of any type of sensation over the transplant. On February 6, 1927, there was a protopathic response to pin prick stimulation over the flap except for a small area distally where pin prick was not felt. Tactile stimuli were recognized but less acutely than normal. Cold sensibility was recognized everywhere over the transplant (Fig. 4).

CASE 8. L. K. The wrist and palm of the right hand were lacerated severely in an automobile accident. Infection and deforming scar contractures resulted. In September, 1924, a pedicle transplant was transferred from the lumbar area to the hand. On January 23, 1925, there was a definite protopathic response to pin prick over the entire flap, except over 2 areas which were the most distal. Tactile sensation could be recognized only about the periph-

Fig. 5. Case 8.

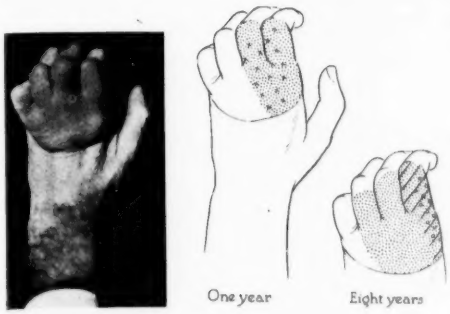

Fig. 6. Case 12.

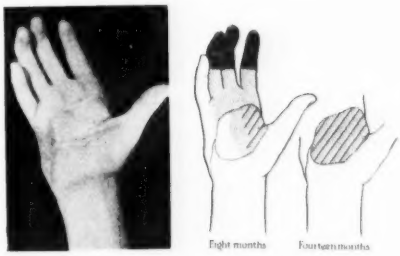

Fig. 7. Case 14.

cy of the transplant. Cold sensation was recognized in scattered areas. On March 25, 1925, the response to pin prick stimuli had become more painful. Tactile stimuli were recognized over the entire transplant but in scattered areas. The orderly progress of the latter sensation from the periphery had ceased (Fig. 5).

CASE 9. S. D. The palmar surfaces of all of the fingers were severely burned and flexor contractures were the result. Pedicle transplants were transferred from the lumbar region in July of 1925. The patient was not examined until May 31, 1927, when pin prick, tactile, and cold sensibility were all recognized.

CASE 10. G. C. This boy received a severe rope burn of the left hand which resulted in contractures and partial amputations. A pedicle flap was transferred from the lumbar region to the fingers in July of 1925. There were no lesions of the peripheral nerve trunks. On February 3, 1927, the transplanted skin was sensitive to pin prick, touch, and cold stimuli. There was no typical protopathic response but there was a definite hyperalgesia and hyperæsthesia.

CASE 11. O. N. This patient's flexor tendons, median and ulnar nerves were divided at the wrist in an automobile accident. The wound became infected and there was a considerable loss of tissue. A pedicle transplant was transferred from the lumbar region to the wrist in February of 1926. An examination in March of 1927 showed a complete return of sensation to pin prick and tactile stimuli. There was no recovery of sensation in the hand in the areas supplied by the median and ulnar nerves.

CASE 12. J. O. This patient received a severe injury to the left hand. The ulnar nerve and flexor tendons were cut and there was a loss of tissue over the dorsum of the hand. A pedicle transplant was transferred from the abdomen February 23, 1926. On February 6, 1927, pin prick was recognized, accompanied by a very marked protopathic response and withdrawal over the radial half of the transplant. Tactile sensation was absent. Neither pin prick nor tactile stimuli were recognized over the ulnar side of the transplant, although pressure stimuli were recognized. On February 5, 1934, tactile and cold stimuli were recognized over the radial side of the transplant. Pin prick was felt except over the ulnar side of the flap (Fig. 6).

CASE 13. F. G. Scar tissue resulting from a burn was removed from the web between the right thumb and index finger. A pedicle transplant was transferred from the abdomen on April 6, 1926. On April 11, 1927, sensation to pin prick, touch, temperature, and two point discrimination was present over the entire flap. There was some slight hyperalgesia and hyperæsthesia at the edges of the transplant.

CASE 14. H. W. In November of 1925 the patient received a shot gun charge in the palm of the right hand. A pedicle transplant was transferred to the hand from the lumbar area in May, 1926. In November of 1926 a neurolysis of the branches of the ulnar and median nerves in the palm was done. January 28, 1927, there was partial return of pin prick and tactile sensibility over the transplant. The distal portion of the palm of the hand, the volar surfaces of the proximal phalanges of the index, middle, and ring fingers, and the entire little finger showed a normal response to pin prick but tactile sensation was absent. The distal two phalanges of the index, middle, and ring fingers were analgesic and anæsthetic and ulcers were present on the tips of the middle and ring fingers. Sensation over the thumb was normal. July 29, 1927, sensation over the transplant was normal; pin prick was felt over the fingers but tactile sensibility was still imperfect (Fig. 7).

CASE 15. E. McF. Scar tissue following a severe burn of the right hand was removed and a pedicle transplant from the abdomen was transferred to the palm and volar surfaces of the ring and little fingers. On February 5, 1927, there was complete sensory recovery to pin prick, cold, and tactile stimuli over the entire transplant. A slight protopathic response to pin prick was still present.

CASE 16. B. B. The patient received a crushing injury of the dorsum of the right hand and a pedicle flap was transferred from the abdomen in 1926. The patient was not seen again until January 5, 1934. Pin prick, heat, cold, and tactile stimuli were recognized over the entire transplant. Sensation to touch was diminished as compared to the normal skin.

CASE 17. S. H. The patient had a deforming scar contracture of the right hand resulting from a burn

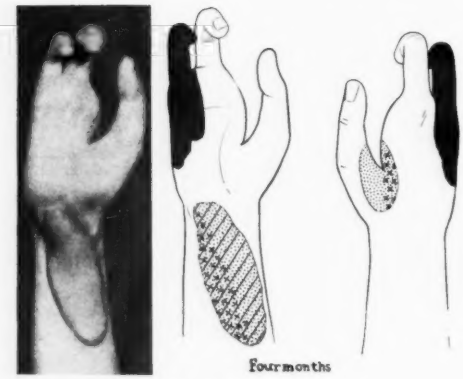

Fig. 8. Case 19.

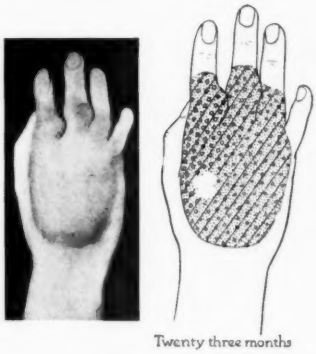

Fig. 9. Case 20.

suffered 22 years previously. A pedicle transplant was transferred from the lumbar region to the hand on July 5, 1926. On January 28, 1927, the patient recognized pin prick stimuli over the entire flap. A painful sensation radiated from each stimulus. Three months after the transplant was transferred, the patient, a doctor, recognized pin prick. Cold stimuli were not recognized and tactile sensation was present but diminished.

CASE 18. B. G. This patient had a pedicle transplant transferred from the lumbar area to cover a defect in the palm which resulted from the dissection of a severe burn scar contracture in July of 1926. On February 27, 1927, sensation to pin prick, touch, and temperature stimuli was normal over the entire transplant. A protopathic response was not present. There was a slight loss of touch and pin prick along the radial side of the ring finger, probably the result of an injury to the digital nerve.

CASE 19. G. S. A high voltage electric burn was followed by a lesion of the ulnar nerve and a deforming contracture of the right hand. Pedicle flaps from the lumbar area were transferred to the hand between the thumb and second metacarpal and to the volar surface of the forearm on November 1, 1926. Sensation in the hand was lost over the ulnar distribution. The nerve was sutured. On March 3, 1927, there had been no sensory recovery in the hand. Pin prick was recognized over the entire forearm transplant and a withdrawal reflex occurred with each stimulus over the ulnar side. Cotton wool was appreciated more acutely over the ulnar half of the flap than elsewhere. Cold stimuli were appreciated. A protopathic response to pin prick occurred only over the ulnar half of the transplant between the thumb and index finger. Tactile and cold stimuli were not recognized over this transplant (Fig. 8).

CASE 20. E. R. On March 3, 1929, the right hand was severely injured in a laundry mangle. Scar tissue involved the dorsum of the hand and fingers as far as the first interphalangeal joints. There was almost complete loss of motion of all four fingers. On November 6, 1929, a pocket flap from the right thigh had been transferred completely to the dorsum of the hand. Later arthroplasties and tendon transplantations were performed so that examination of sensation could not be done accurately until October 26, 1931. Pin prick, touch, and cold stimuli were felt over entire flap except for a small area near radial border. Here pin prick was recognized less accurately and cold and tactile sensation were lost (Fig. 9).

CASE 21. B. McL. On July 17, 1930, the patient fractured three fingers and received a severe laceration of the dorsum of the left hand. On December 17, 1930, a pedicle transplant had been transferred completely from the thigh. November 25, 1931, pin prick and cold stimuli were recognized over the entire transplant. There was a loss of tactile sensation in the web between the index and middle fingers.

CASE 22. G. A. The patient received a gunshot injury of the left forearm which divided the ulnar and median nerves just proximal to the wrist and all of the superficial flexor tendons. An abdominal pedicle flap was transferred on March 27, 1931. On October 19, 1931, a protopathic response to pin prick stimuli and tactile sensibility was present over a small area on the ulnar side of the transplant. On February 1, 1934, there had been no recovery of sensation in the median and ulnar distribution over the palm or fingers. Pin prick was recognized over the transplant but at its distal edge the stimulus was accompanied by a protopathic response. Tactile stimuli were appreciated only at the proximal edge of the transplant and each stimulus evoked a protopathic response similar to that produced by pin prick. Cold stimuli were recognized everywhere without an unpleasant spread of the sensation (Fig. 10).

CASE 23. A. K. On July 30, 1930, the left hand was crushed and burned in a laundry mangle. On August 18, 1931 a thin, translucent pedicle flap was transferred from the thigh to the dorsum of the hand. In some areas it had been necessary to scrape the scar tissue from the bone. On October 19, 1931, there was a complete sensory loss to pin prick, cotton wool, and cold stimuli over the entire flap except for

Fig. 10. Case 22.

slight recognition of pin prick at the distal end of ne transplant over the index finger. On February 1, 934, there had been a complete return of pin prick, ouch, and cold sensation over the entire flap. There was no protopathic response.

CASE 24. J. G. A pedicle transplant was transferred to the dorsum of the right hand between the thumb and index finger on October 13, 1929. On November 21, 1931, sensation to pin prick, touch, and cold stimuli was normal over this area of skin. In June, 1930, a similar transplant was made to the ulnar border of the right hand. Twenty months later sensation to pin prick, touch, and cold stimuli was normal over that transplant. On October 25, 1931, a pedicle transplant was transferred to the palmar surface of the thumb. On November 21, 1931, there was a small area of sensory return to pin prick over the distal surface of the transplant.

A pedicle transplant was transferred to the palm of the left hand in March of 1931. On November 21, 1931, pin prick sensation had advanced from the periphery to a small oval area of loss in the center of the transplant. Tactile and cold sensibility was absent over the entire flap. A small area of the transplant at its proximal border was removed for microscopic study of nerve endings November 21, 1931.

CASE 25. V. S. On June 9, 1932, the patient received a severe denuding injury of the dorsum of the left hand and fingers. Denudation was complete except for a small area of skin over the dorsolateral surface of the hypothenar eminence. The ring finger was amputated traumatically and the rest were removed later, leaving only the thumb and little finger. On July 29, 1932, a pedicle abdominal flap had been transferred completely to the dorsum and palmar surfaces. Areas of the latter portion of the transplant melted away and were replaced by free full thickness and Thiersch grafts in October of 1932.

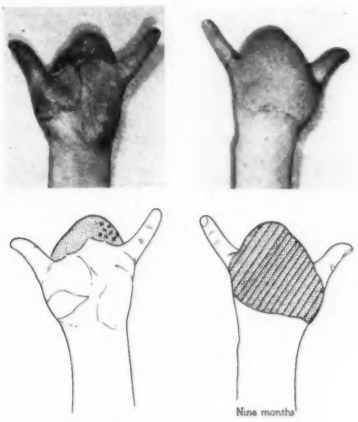

Fig. 11. Case 25.

On April 12, 1933, pin prick and tactile stimuli were recognized over the dorsal transplant. The patient was hypersensitive to tactile stimuli. Pin prick but not touch was recognized over the free full thickness transplant. There was a small area of hyperalgesia over this graft. Neither pin prick nor tactile stimuli were recognized over the Thiersch graft (Fig. 11).

CASE 26. W.F.C. An X-ray burn of the left hand was followed by an ulcer on the dorsum of the left index and ring fingers and amputation of the middle finger. A pedicle transplant from the abdomen was transferred to the index finger on November 7, 1932 and to the ring finger on January 15, 1933. On May 17, 1933 pin prick, cold, and tactile sensations were present over the index finger transplant except over its most distal portion. There the loss of pin prick was less than that of touch. There has been no return of tactile or pin prick sensation over the ring finger (Fig. 12).

CASE 27. R. G. The patient received an electric wire burn of the right forearm, and in November of

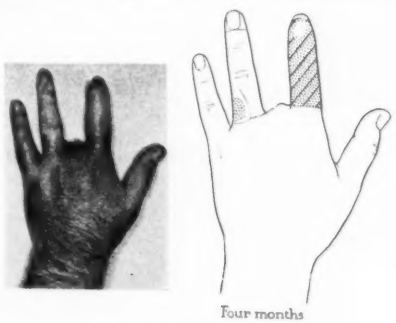

Fig. 12. Case 26.

Fig. 13. Case 27.

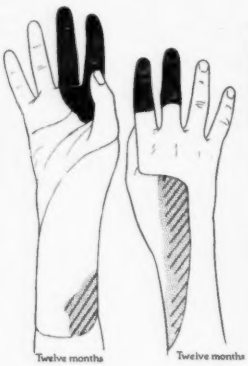

Fig. 13.

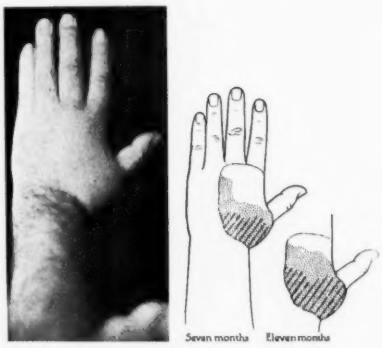

Fig. 14. Case 28.

1932 a large pedicle transplant was transferred from the abdomen. The median nerve had been divided and was sutured. On November 22, 1933, pin prick and touch stimuli were recognized over the ulnar side of the dorsal surface of the flap. The entire volar surface of the transplant was analgesic and anæsthetic except for a small area on the radial side at its proximal extremity. The return of pin prick sensibility was greater than that of touch and no protopathic response was present (Fig. 13).

Case 28. P. McC. The patient received a laceration of the dorsum of the hand in an automobile accident September 11, 1932. An abdominal pedicle flap was transferred on March 31, 1933. Upon examination May 24, 1933, there was no response to any type of sensory stimulus. On October 30, 1933, pin prick and cold sensibility was present over the proximal portion of the transplant. Tactile stimuli were recognized in this same area but this was below normal. Only pressure sensation was present in the distal half of the transplant.

On February 1, 1934, sensation to pin prick and touch had advanced distally, and as before the latter was less in extent than pin prick. Cold stimuli were recognized in the area of return to pin prick. There was no protopathic response from any type of stimulation (Fig. 14).

Case 29. F. M. In an automobile accident August 10, 1931, the patient received a compound fracture of the right humerus and of both bones of the right forearm. The median nerve was divided. A gas bacillus and streptococcic infection developed. On June 23, 1933, the median nerve was sutured and in August of 1933 an abdominal pedicle flap was transferred completely to the forearm. On November 24, 1933, pin prick and tactile sensation was present over the radial half of the volar surface of the transplant. The dorsal surface of the transplant was insensitive except for a small area on the radial side where pin prick and touch were recognized. Loss of all sensations was present over the volar surface of the index finger. Sensation over the rest of the palm of the hand and fingers was normal.

On January 1, 1934, there had been no advance in the area in which pin prick and touch were recognized on the volar surface of the forearm. However, both stimuli elicited a very painful, spreading, "electric shock" sensation which had not been present before. On the dorsum of the forearm pin prick had advanced from the radial side to the scar joining the edges of the transplant. There was no protopathic response. Touch was recognized in this same area. On the ulnar side of the dorsum of the forearm, pin prick was recognized at the distal edge of the graft and was accompanied by a marked protopathic response (Fig. 15).

Case 30. J. P. A pedicle transplant from the abdomen was transferred to the volar surface of the right forearm to cover a traumatic defect on October 11, 1933. The median nerve was injured and sensation was lost over the palmar surface of the index finger. Elsewhere in the hand sensation was normal. On November 21, 1933, there had been no recovery to pin prick, cold, or tactile stimulation over the transplant although pressure was recognized easily. A split graft from the thigh was used to cover the abdominal defect. On the same date of examination there had been no recovery of sensation.

Case 31. A. B. In June, 1928, a free full thickness graft was taken from the thigh to cover a defect in skin on the volar surface of the left elbow. The median, ulnar, and radial nerves were uninjured. On November 24, 1933, there had been no return of sensation to pin prick, touch, or cold stimuli at any point over the transplant.

Case 32. E. B. A free full thickness transplant was transferred from the thigh to the palm of the right hand in August, 1931. The patient had suffered a severe burn from X-ray treatment for dermatitis. On November 24, 1933, pin prick and tactile stimuli were recognized over the entire flap. There

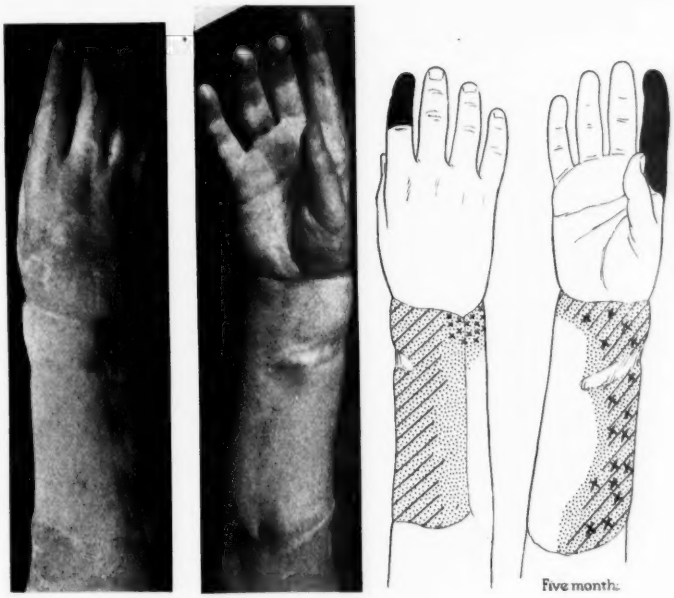

Fig. 15. Case 29.

was no protopathic response but the sensation was not as acute as over the skin on dorsum of hand.

Case 33. F. M. This patient's hand was injured in a laundry mangle. In March of 1932 a free full thickness transplant was placed in the palm and on the volar surfaces of the index, middle, ring and little fingers after dense scar tissue had been removed. Part of the transplant to the index finger melted away and in July of 1932 a pedicle transplant was transferred to the tip of that finger. In October, 1933, sensation to pin prick, touch, and cold stimuli was normal over the free full thickness transplants except for a small area at the proximal edge of the graft at the base of the ring finger. In this area none of these stimuli was recognized. There was a small area in the center of the small pedicle flap where pin prick and touch sensation were diminished. On the edges of that transplant there was a protopathic response to pin prick stimuli (Fig. 16).

Case 34. W. R. Contractures of the ring and little fingers of the right hand resulted from a burn. A free full thickness graft was taken from the thigh in December of 1926 to cover the defect which followed removal of the scar tissue. On April 25, 1927, pin prick and tactile sensation were present over transplant but were diminished slightly over fifth finger.

Case 35. S. R. The left hand was caught in a pulley and a scar contracture of the fourth and fifth fingers developed. A free full thickness transplant was transferred from the abdomen in June of 1926. On March 31, 1927 tactile and pin prick stimuli were recognized over the entire graft.

Case 36. F. B. A rope burn resulted in a severe contracture of the fingers of the left hand. A free full thickness transplant was transferred from the abdomen to the flexor surfaces of the index, middle, ring and little fingers in January, 1927. On examination in March of 1928 tactile and pin prick stimuli were recognized over the entire flap. There was no evidence of a protopathic response.

Case 37. D. R. The patient was treated for pruritus ani by X-rays and received a severe burn of the right buttocks. When the involved skin had been removed a Thiersch graft was placed over the defect in March of 1932. The area grafted measured about

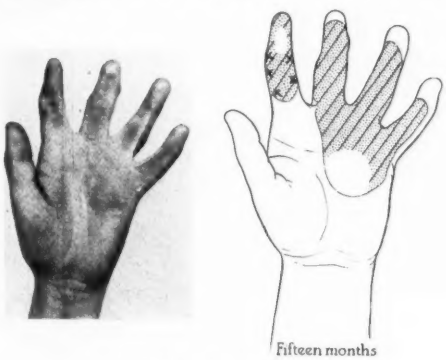

Fig. 16. Case 33.

Fig. 17. Case 39.

12 by 5 centimeters. On November 17, 1933, the patient recognized pressure stimuli over the entire graft but pin prick, touch, and cold stimuli were present only in a small area near the upper margin of the transplant.

CASE 38. A. F. In June of 1931 a free full thickness graft was placed on the dorsum of the right hand to cover a defect in skin which followed an automobile accident. On December 22, 1933, although pin prick and tactile stimuli were recognized over the transplant there was a definite hypæsthesia and hypalgesia.

CASE 39. W. T. The patient had an X-ray ulcer of the back which was removed by a wide dissection. A Thiersch graft to this area was not successful. A skin flap was moved up to cover the defect and a Thiersch graft was used to cover the area from which the flap had been shifted. The Thiersch graft was applied in August, 1933. On November 23, 1933, pressure touch was recognized but tactile sensation was absent. Pin prick stimuli were recognized in two small areas and there was no protopathic response (Fig. 17).

DISCUSSION

Several generalizations may be made about the return of sensation in transplanted skin. In this material the return of sensibility has been more complete in the pedicle transplants. Sensation has recovered more rapidly in those pedicle transplants which have had only a small amount of subcutaneous tissue attached to the skin. The return of sensation to Thiersch and free full thickness grafts has not been as complete as one might expect, although several of these types of transplants were made to areas injured by X-ray exposures. It is possible that nerve endings and fibers had been destroyed permanently by that agent.

Fig. 17.

Kredel and Evans (7) emphasized the question of the polarity of the pedicle flaps and its effect upon the return of sensation. Although this was not studied throughout the 14 years of observing and examining these patients, a review of the operative notes and sketches brings a conclusion in agreement with them. Changing the polarity of the transplant does not affect the time or character of the return of sensation.

In every instance there was a dissociation between the recovery of pin prick, touch, and temperature sensation. Pin prick sensibility always recovered first and the area of return of tactile sensibility was therefore within that of pin prick. In every case when examinations were made at frequent intervals after operation a hyperalgesia was present which resembled Head's protopathic pain. The painful sensation spread like an electric shock from the point of stimulation and the point of the stimulus could not be localized. This reaction began to disappear as tactile stimuli were first recognized. As touch sensibility became more definite and advanced, the protopathic response with reflex withdrawal disappeared entirely. Cold stimuli were recognized in the area occupied by the recovery of pin prick sensibility. In a very uniform manner in the pedicle flaps, sensation advanced from the edges of the transplanted skin to the center and the progression advanced more distally than in a perfect circular fashion. In Thiersch

and free full thickness transplants return of sensibility in patches was more common.

It is difficult to believe that old sheath cells play an important rôle in regeneration and the recovery of sensation. It is more likely that the severed ends of nerve fibers in the normal skin and subcutaneous tissue to which the transplant becomes attached send processes into the graft which in the beginning are devoid of myelin sheaths. In an effort to study the type of nerve fibers in transplanted skin to which sensation had returned, specimens of skin were removed from three pedicle grafts and one Thiersch graft. In one instance the pedicle transplant had been in place 3 years; another 1 month, and the third, 3 months. The Thiersch graft had been applied 34 days previously and had shown no evidence of return of sensation. In each of the pedicle transplants there had been a return of pin prick sensation and in one, tactile stimuli were appreciated. The specimens were divided into smaller blocks and in one, serial sections were mounted. They were stained by the Bielschowsky technique. In one half of the sections a counterstain was made with hæmatoxylin.[1] Nerve fibers were not found in any of the specimens, neither medullated nor nonmedullated. Had the axons failed to impregnate, the hæmatoxylin counterstain would have made it possible to detect with ease any medullated nerves had they been present.

Observations upon a transplant placed over the volar surface of the index finger with the median nerve severed at the wrist, for example, have not been made. Neither are there examples of transplants over other isolated areas of nerve supply. The examination of such a transplant will afford valuable evidence of sensory return. The nearest approach to this situation was in Case 12 in which the ulnar nerve was cut. After 8 years sensation to pin prick had progressed slowly ulnarward but even at that time the little finger portion of the transplant was analgesic. There are other questions which cannot be answered as yet because just the correct combination of clinical conditions have not been present.

The fact that pin prick stimuli are recognized first and that when tactile stimuli elicit a response the extremely painful character of the pin prick disappears may be observed repeatedly. These facts are in agreement with those of Boeke and Heringa. They also are evidence that this type of sensory return is due to nerve overlap as Pollock has claimed in recovering peripheral nerve lesions. He has stated that recovery of sensation in the isolated supply occurs simultaneously for all types. In our experience touch sensation has never returned first. It should be emphasized again that tactile sense and pressure sense are two different things; the latter involves the muscles, tendons, and bones. We cannot find sufficient evidence to state that simply because the return of sensation is dissociated this alone is direct evidence of the existence of separate fiber pathways in the peripheral nerves for each type of sensation.

It has been noted that sensation has begun to recover as early as 4 to 5 weeks. In some cases it has not recovered completely after many years. The rate and extent of recovery depend upon the type of the transplant, its thickness, the presence of scar tissue, and the state of the adjacent peripheral nerves which have cutaneous branches in the area involved.

[1]Dr. H. J. Wilkinson, Professor of Anatomy at The University of Adelaide, very kindly made these microscopic studies. Professor Wilkinson has had a large experience in the use of this staining method which he perfected. He said, "If any non-medullated nerves exist in the blocks examined, my staining method failed to reveal them. This, of course, is possible. If the technique has failed, however, it is the first time since I returned, and I can only suggest that the common method in use for the formalin fixation of tissues is at fault."

BIBLIOGRAPHY

1. Boeke, J., and Heringa, G. C. Verhandl. Konink. Akad. u. Wetenschappen te Amsterdam, 1924, xxvii, nos. 9 and 10.
2. Boring, E. G. Quart. J. Exper. Physiol., 1916, x, 1.
3. Davis, J. S., and Traut, H. F. Lewis' Practice of Surgery, v, Chapt. 8. Hagerstown, Maryland: W. F. Prior Company, 1931.
4. Dubreuilh, W., and Noel, P. Rev. de chir., 1911, xliii, 83.
5. Head, H., Rivers, W. H. R., and Sherren, J. Brain, 1905, xxviii, 99.
6. Kadanoff, D. Arch. f. Entwcklngsmechn. d. Organ., 1925, cvi, 249.
7. Kredel, F. E., and Evans, J. P. Arch. Neurol. & Psychiat., 1933, xxix, 1203.
8. Pollock, L. J. Arch. Neurol. & Psychiat., 1919, ii, 667.
9. Sharpey-Schafer, E. Quart. J. Exper. Physiol., 1928, xix, 85.
10. Stransky, E. Wien. klin. Wchnschr., 1899, xii, 815, 833.
11. Trotter, W., and Davies, H. M. J. Physiol., 1909, xxxviii, 134.
12. Williams, G. A. Arch. Surg., 1928, xvi, 938.

EARLY AMERICAN MEDICAL SCHOOLS

NORTHWESTERN UNIVERSITY MEDICAL SCHOOL

J. ROSCOE MILLER, M.S., M.D., CHICAGO

NORTHWESTERN University Medical School has the distinction of being the first to introduce a graded curriculum into medical education in the United States. In fact, the keen desire of its founders to introduce this innovation was responsible for the founding of the school.

In the early part of the nineteenth century there were only four medical schools in the United States. These offered two courses of instruction of approximately sixteen weeks each and granted a diploma (Doctor of Medicine), the possession of which was sufficient to allow the owner to practice medicine. The number of graduates from these four schools was small. The laws of many states allowed apprenticeship in a practicing physician's office for a period of three or four years, to be substituted for the two year medical course. After this period of training had been served, an examination was given by the censors of an organized medical society, and if successfully passed, the candidate was licensed to practice. Attendance at one of the established medical schools, however, deducted one year from the period required in a practitioner's office, and it soon became well known that it required less time and money for a young man to apprentice himself for a period of three years, at the same time being registered in a medical school, than to serve four years and then be required to take the examination. As a consequence the existing medical schools were besieged by anxious applicants for entrance. The result was the establishment throughout the country of numerous medical colleges. As these were run solely on the funds collected from the students and as the latter desired the degree of Doctor of Medicine more than the training, the standards set were negligible. By 1850 there were thirty-six medical schools turning out thirteen hundred graduates each year. No preliminary education was required and attendance at lectures was dependent entirely on the students' wishes. The school "year" consisted of twelve to sixteen weeks during which courses of lectures were given. These were not arranged in any logical sequence and the second "year" consisted of a repetition of the first.

Nathan Smith Davis

In 1844 Nathan S. Davis, a young delegate from the Broome County Medical Society, suggested to the New York State Medical Society at its annual meeting that some plan be formulated whereby medical and premedical education could be systematized and standards established. The persistent work of Dr. Davis resulted in the founding of the American Medical Association in May, 1847, the prime object of this organization being the elevation and standardization of medical education in the United States.

In 1849 Dr. Nathan S. Davis was offered a position on the faculty of Rush Medical College (Chicago), which he accepted. He thereupon changed his address but not his views

n medical education. At Rush he met a number of men who shared his opinions, but the majority of the faculty and trustees were not in agreement, nd in 1859 a small group left Rush Medical Col-ge to establish the medical department of Lind niversity, an institution named for Sylvester ind, a Chicago business man. Lind University ad recently received a liberal charter from the tate.

The six men who undertook the task of organ-ing a new medical school along the lines they had long advocated were Drs. Hosmer A. Johnson, dmund Andrews, Ralph N. Isham, David utter, Nathan S. Davis, and William H. By-rd. The curriculum which they inaugurated nsisted of two consecutive college years of five onths each, so arranged that dissection and boratory work were taken the first year and spital clinical instruction the second year. A ird year, largely clinical in character, was commended and urged but not required for raduation.

The school was located in the five-story brick Lind Block" at Randolph and Market Streets, nd the first term began October 9, 1859. The nrollment was thirty-three, fourteen of the stu-ents being seniors who had completed at least ne year in another medical school. The faculty f this pioneer school was constituted as follows: David Rutter, M.D., emeritus professor of obstetrics; Hosmer A. Johnson, M.D., professor of materia medica and therapeutics; Edmund Andrews, M.D., professor of principles and practice of surgery; Ralph N. Isham, M.D., professor of surgical anatomy; Nathan S. Davis, M.D., professor of principles and practice of medicine; William H. Byford, M.D., professor of obstetrics and diseases of women; John H. Hollister, M.D., professor of physiology and histology; F. Mahla, M.D., professor of chemistry and toxicology; M. R. Taylor, M.D., professor of general pathology; Titus Deville, M.D., professor of descriptive anatomy; Henry G. Spofford, Esq., professor of medical jurisprudence; and Horace Wardner, M.D., demonstrator of anatomy.

The first year was a success and nine members of the senior class were graduated March 5, 1860. During the second year there were fifty-one students and in the third year, sixty-three.

The outbreak of the Civil War brought about drastic changes in the medical school as many members of the faculty resigned to serve in the Army. The school work continued, however, and the number of matriculants increased to seventy-nine in the fourth year. The five month college term had been augmented by four months of

Lind Block. The Medical department of Lind University occupied the third and fourth floors of this building from 1859 to 1863.

clinical instruction during the summer. Due to the Civil War, Sylvester Lind was in financial difficulties and was unable to fulfill his pledge of $100,000 to the University. The medical faculty was thereby released from its original terms of agreement, and at the opening of the regular college term in 1863 it was decided to continue the school as an independent unit under the name of the Chicago Medical College. A new building was erected at 22nd and State Streets. The *University Bulletin* of this period credits the medical school library with the possession of one thousand bound volumes and the leading medical periodicals of the time. Clinical teaching was carried on at Mercy Hospital, which had been organized by Dr. N. S. Davis, Judge T. Lyle Dickey, Judge Mark Skinner, Captain R. K. Swift, and Dr. John Evans. It had its beginning in 1850 as "The Lake House," where the nursing was done by medical students. It was taken over by the Sisters of Mercy and named Mercy Hospital in 1851. From this period until 1919 Mercy Hospital was used for much of the clinical teaching done by Northwestern University Medical School.

In 1869 the Chicago Medical College became the medical department of Northwestern University but the affiliation was a loose one. The University granted the degree of Doctor of Medicine to those students recommended by the faculty. Undergraduates in the school of liberal arts were allowed to study chemistry in the medical school. The latter retained title to its property and managed its own finances. At this time Northwestern University advanced $45,000.00 to the medical school for a new building

The Chicago Medical College, 1870–1892.

and pledged $1,000.00 each year to apply on the salary of the professor of chemistry. For the following twenty years this affiliation continued unchanged. The medical department was still the only one in the United States with a graded curriculum.

In 1870, having again outgrown its quarters, the medical school was moved to a new building adjoining Mercy Hospital at 26th and Prairie Avenue, and the association between the two institutions became closer, the professors of clinical subjects teaching at the hospital.

In 1890 all property of the medical school was given in trust to the University and the name changed to Northwestern University Medical School. The entrance requirements were made equivalent to one year in high school and a four-year course of medical study was a prerequisite to obtaining the doctor's degree. At the same time the college year was increased from five to seven months. In 1897 the requirements became the same as those necessary to enter the school of Arts and Sciences.

In 1890 William Deering, long a staunch friend of the medical school, aided in the purchase of a tract of land at 25th and Dearborn streets. Here a building was erected for the schools of medicine, dentistry, and pharmacy. Adjoining this building a small two story brick structure was built to house Wesley Hospital. In 1901 a new hospital building was constructed on the same site and additions made in 1910. From its founding to the present date Wesley Hospital has maintained a close affiliation with the medical school and much of its clinical teaching has been done there.

The medical building erected on south Dearborn Street and occupied in 1893 was at the time one of the best medical plants in the country. Gradually the space occupied by the departments of dentistry and pharmacy was needed by the medical school and by 1901 the medical school occupied the entire building. In 1894 William Deering augmented his previous gifts by $50,000.00 to be used as an endowment for the chair of physiology. This was named for Dean N. S. Davis. Later the chair of anatomy was endowed by the widow of a former professor of anatomy and named in his honor, the Robert Laughlin Rea professorship. N. S. Davis, Jr., son of the illustrious founder, became dean in 1901, an office he filled until 1907. In 1910 James A. Patten, philanthropist, established an endowment of approximately one-half million dollars, the income of which was to be used for research in bacteriology.

In 1913 plans were discussed by the trustees of Northwestern University for the opening of a downtown campus to provide for all the professional schools of the university. In 1917 an option was secured on a site located on Lake Shore Drive at Chicago Avenue, and June 15

Photograph by Fowler

Northwestern University, McKinlock Campus. The Medical School, The Montgomery Ward Memorial, in left foreground, Passavant Memorial Hospital to right.

1920 the nine acre tract was purchased by the University at a cost of $1,420,260.00. This purchase was made possible by the activities of Mr. William A. Dyche, business manager of the University, and the generosity of Mr. Milton H. Wilson.

In 1921 a gift of $250,000.00 was made to the University by Mr. and Mrs. George A. McKinlock in memory of their son, George Alexander McKinlock, Jr. By order of the board of trustees the new Chicago campus was named the Alexander McKinlock Jr. Memorial Campus, in honor of Alexander McKinlock Jr. and his comrades who lost their lives during the World War.

In December, 1923, Mrs. Elizabeth J. Ward, widow of Chicago's great merchant, gave $1,000,000.00 to Northwestern University for the erection of a memorial to her husband, A. Montgomery Ward. Shortly thereafter this gift was augmented by three millions, the sum to be used for a building to house the medical and dental schools. In 1926 Mrs. Ward added to her previous gifts $4,000,000.00, which last sum was to be used for endowment, scholarships, and fellowships. In making her initial gift, Mrs. Ward said:

It has been called to my attention that Northwestern University has recently acquired a site for an urban campus on the lake shore at Chicago Avenue, designated to accommodate a medical center, a school of commerce, a school of law, and other departments, all housed in suitable buildings. This campus offers opportunities particularly appropriate for the memorial which I have had in mind . . . .

It is my belief that Chicago, situated as it is in the center of the district rich in agricultural and natural resources in the United States, protected by the pendulum of Lake Michigan, is destined to become a great city including in its greatness permanent centers for all forms of philanthropic and educational work. Northwestern University, the first university founded within the City of Chicago, has been steadily developing, but with its plans for future growth will more fully realize its opportunities and continue to develop as the city develops.

Endowed universities seem to me to be the most enduring of all human institutions, and Northwestern University by its location and by its history, seems destined to endure . . . .

I have selected as a memorial the medical center, because of its commanding site overlooking the lake, because it will render a very large measure of service to humanity and because it will be as enduring a memorial as can be devised.

The plan taken as a whole seems to me to make adequate provision for centers of medicine, law, and commerce, with ideals of quality rather than quantity . . . .

The new medical center of Northwestern University shall conduct approximately the following activities:

Individual. To impart available medical and related knowledge to students, internes, postgraduates, nurses, and social service workers.

Humanitarian. To advance the frontiers of medical and related knowledge through research, to acquire knowledge of the natural history of disease, leading to the prevention of disease and to improve existing methods of treating disease.

Civic. To render community health service by promoting periodic medical examination; also, by efforts to readjust the occupational and social life of those in the incipient stages of disease and by the treatment of disease.

The ground breaking ceremonies were held May 8, 1925, a day selected because it marked the seventy-fifth anniversary of the founding of Northwestern University. This building is the present home of the medical school which occupies the first seven and fourteenth floors of the building proper and the first and fifth floors in the tower. The out patient department has been carefully planned and took care of over 130,000 patients last year. Adequate room is furnished for didactic and research work, 89 students being engaged in the latter phase of medical education.

In 1925 Dr. Irving S. Cutter, formerly dean of the medical school at the University of Nebraska, came to a similar position at Northwestern University.

In 1926 an affiliation was effected with Passavant Memorial Hospital, and in 1929 this institution erected a two million dollar building on the McKinlock Campus. In 1930 the Evanston General Hospital, also, was affiliated. These two hospitals, together with Wesley Hospital, now constitute a triad where clinical instruction is carried on, the staffs being named by the medical school. Other Chicago institutions where clinical instruction is received by the students are St. Luke's, Michael Reese, Children's Memorial, St. Joseph's, Cook County, Norwegian American, and Illinois Masonic Hospitals.

The Archibald Church Library, endowed by Archibald and Margaret Finch Church, now numbers more than 66,000 bound volumes and contains many of the classics of medicine, as well as considerable source material.

Since its establishment in 1859 Northwestern University Medical School has graduated 5,119 physicians of whom approximately 3,900 are living and are in active practice. Among the many distinguished graduates may be mentioned: Dr. James S. Jewell, founder and first editor of the *Journal of Nervous and Mental Disease*, Frank Billings, prominent internist and medical educator; Charles Mayo, joint founder of Mayo Foundation for Medical Education and Research; Franklin Martin, who established SURGERY, GYNECOLOGY AND OBSTETRICS, and organized the Clinical Congress of Surgeons of North America and the American College of Surgeons; Joseph B. DeLee, founder of Chicago Lying-In Hospital and author of *Principles and Practice of Obstetrics;* Howard T. Ricketts, who discovered the rôle of the wood tick and body louse in transmission of Rocky Mountain Spotted Fever and Mexican typhus; Isaac A. Abt, author of *System of Pediatrics;* Allen B. Kanavel, author of *Infections of the Hand;* John A. Fordyce, editor of *Archives of Dermatology and Syphilology;* professor of dermatology at College of Physicians and Surgeons, New York; Charles D. Lockwood, one of the founders and first president of Pacific Coast Surgical Association; and Nicholas Senn, prominent Chicago surgeon.

As from the beginning, instruction has been consistently maintained at a high level, representing the best in laboratory and clinical science. The emphasis has been and is on training physicians for the practice of medicine, although research is fostered and stimulated to an unusual degree. One hundred twenty students are accepted in each of the first two years of the medical course proper, and 130 in each of the two clinical years.

BIBLIOGRAPHY

1. Northwestern University; A History, 1855–1905. Edited by Arthur Herbert Wilde, 1905.
2. History of Medicine and Surgery and Physicians and Surgeons of Chicago. The Biographical Publishing Corporation, 1922.
3. Dedication of the Montgomery Ward Memorial Building, Northwestern University Medical School, Alexander McKinlock Memorial Campus, Chicago. June 15, 16, and 17, 1927 (Lakeside Press).

CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

WILLIAM D. HAGGARD, Nashville, *President* ROBERT B. GREENOUGH, Boston, *President-Elect*
FRANKLIN H. MARTIN, Chicago, *Director-General*
ARTHUR W. ALLEN, *Chairman;* ERNEST M. DALAND, *Secretary, Committee on Arrangements*

PRELIMINARY PROGRAM FOR CLINICAL CONGRESS IN BOSTON

IN the following pages will be found the preliminary program of clinics and demonstrations as prepared by the Committee on Arrangements for the twenty-fourth annual Clinical Congress of the American College of Surgeons to be held in Boston, October 15–19. The surgeons of that great medical center have organized under the leadership of a strong and representative committee and are planning to provide for the Fellows of the College and their guests a program of surgical clinics that will present a complete showing of their clinical activities in all departments of surgery. The Committee on Arrangements has been assured of the hearty cooperation of the clinicians at the medical schools and more than thirty hospitals that will participate in the program.

It will be noted that operative clinics and demonstrations in the hospitals are scheduled for the afternoon of Monday, October 15, beginning at 2 o'clock, and for the mornings and afternoons of each of the four following days. The schedules here published are to be revised and amplified as the work of the Committee progresses during the intervening weeks. The real program will be published daily during the Congress—a complete and accurately detailed program to be posted in the form of bulletins at headquarters each afternoon for the succeeding day. The same material is to be issued in printed form the following morning.

Many special features will be included in the clinical program, among them being: (1) Cancer clinics demonstrating the treatment of cancer by surgery, radium and the X-ray; (2) fracture clinics at which modern methods in the treatment of fractures will be demonstrated; (3) clinics in traumatic surgery for the presentation of methods used in the rehabilitation of injured patients by surgery and physiotherapy.

The Committee on Scientific Exhibits has drawn upon the abundant medical resources of Massachusetts to provide a remarkably attractive and instructive exhibit for the benefit of the Fellows. At headquarters and in the medical institutions of Boston there will be presented unusual exhibits on various phases of historical and current events in the practice of surgery and its specialties, dentistry, anatomy, pathology, public health, and anæsthesia. An exceptional feature will be an exhibition of works of art by Massachusetts physicians.

EVENING MEETINGS

The Central Executive Committee has prepared programs for five evening sessions which are published in the following pages. At the presidential meeting on Monday evening in Symphony Hall, the president-elect, Dr. Robert B. Greenough, of Boston, will deliver his inaugural address. A feature of this session will be the John B. Murphy oration in surgery by Dr. Donald C. Balfour, of Rochester, Minn.

A number of distinguished surgeons from abroad who will be in attendance at the Clinical Congress will be introduced at this session. Among the visiting surgeons will be the following: Dr. Bethel Solomons, Dublin, Ireland; Sir Harold Gillies and Mr. A. Lawrence Abel, London, England; Mr. Harry Platt and Dr. William F. Shaw, Manchester, England; Dr. Alexander MacLennan, Glasgow, Scotland; Dr. Rafael Silva, Mexico City, Mexico; Prof. Josef Halban, Vienna, Austria.

On Tuesday, Wednesday, and Thursday evenings sessions will be held in the ballroom of the Copley-Plaza Hotel at which eminent surgeons of the United States and Canada together with visiting surgeons from foreign countries will present and discuss papers on surgical subjects of timely importance.

At the annual Convocation of the College to be held on Friday evening in Symphony Hall, the 1934 class of candidates will be received into Fellowship in the College.

SYMPOSIUM: CANCER IS CURABLE

Further reports by clinicians from various parts of the United States and Canada, presenting additional statistics on the cure of cancer in addition to reports presented at the 1932 and 1933 sessions of the Clinical Congress, will be included in a symposium on cancer to be presented under the auspices of the Committee on the Treatment of Malignant Diseases in the ballroom of the Copley-Plaza Hotel on Wednesday afternoon. The program for the symposium follows:

Charles A. Dukes, M.D., Oakland, Calif., presiding.
General Subject of Curability of Cancer: Franklin H. Martin, M.D., Director-General.
General Cases of Five Year Cures: Robert S. Cathcart, M.D., Charleston, S. C.; Roy D. McClure, M.D., and Arthur McGraw, M.D., Detroit; Mont R. Reid, M.D., and William Millar, M.D., Cincinnati; Harry C. Saltzstein, M.D., Detroit; Francis Carter Wood, M.D., and Benjamin Rice Shore, M.D., New York.
Cancer of the Stomach and Intestines: William T. Coughlin, M.D., St. Louis.
Cancer of the Pelvic Organs and Breast: Frederick C. Holden, M.D., New York; C. Jeff Miller, M.D., New Orleans.
Cancer of the Breast: Hubert A. Royster, M.D., Raleigh, N. C.; Hugh H. Trout, M.D., Roanoke, Va.
Cancer of the Pelvic Organs: Frederick J. Taussig, M.D., St. Louis.
Cancer of the Genito-Urinary Organs: Edwin Beer, M.D., New York.
Cancer of the Mouth and Larynx: Gordon B. New, M.D., Rochester, Minn.
Lymphatic Tumors: Lloyd F. Craver, M.D., New York.

Following these reports a group of papers descriptive of accepted methods for the treatment of cancer will be presented as follows:

Cancer of the Stomach Treated by Surgery. J. Shelton Horsley, M.D., Richmond, Va.
Cancer of the Cervix Treated by Surgery and Irradiation. George Gray Ward, M.D., New York.
Cancer of the Breast Treated by Surgery and Irradiation. Stuart W. Harrington, M.D., Rochester, Minn.
Cancer of the Lip Treated by Surgery and Irradiation. Ellis Fischel, M.D., St. Louis.
Cancer of the Bladder Treated by Surgery and Irradiation. William E. Lower, M.D., Cleveland.

FRACTURE CONFERENCE

A conference on fractures, under the auspices of the College Committee on the Treatment of Fractures, will be held in the ballroom of the Copley-Plaza Hotel on Tuesday afternoon.

Among the papers to be presented are:

One Thousand Consecutive Fractures of Both Bones of the Leg. William Senger, M.D., in collaboration with J. Sims Norman, M.D., Pueblo, Colo.
Treatment of Fracture of the Carpal Scaphoid. D. W. Gordon Murray, M.D., Toronto.
Fractures of the Jaw. Robert H. Ivy, M.D., Philadelphia.
Acute Fractures. Melvin S. Henderson, M.D., Rochester, Minn.
Further Observations of the Nicola Operation for Recurrent Dislocation of the Shoulder. Toufick Nicola, M.D., New York.

Also, under the auspices of the same Committee, by the use of manikins, splints, tables, and other accessory equipment, hundreds of treated fractures will be practically demonstrated daily as a part of the scientific exhibition in the Statler Hotel ballroom.

CONFERENCE ON INDUSTRIAL MEDICINE AND TRAUMATIC SURGERY

During the past four years the College has conducted investigations and surveys in many parts of the United States to ascertain present medical conditions in industry and to inform employers of adequate methods. The results of these surveys will be presented in the symposium to be held in the ballroom of the Copley-Plaza Hotel on Friday afternoon under the auspices of the Board on Industrial Medicine and Traumatic Surgery. Other papers in the symposium deal with the clinical aspects of injuries occurring in industry and methods of rehabilitation of the injured.

Frederic A. Besley, M.D., Chairman, Board on Industrial Medicine and Traumatic Surgery, presiding.
The Program of the American College of Surgeons in Industrial Medicine and Traumatic Surgery. Franklin H. Martin, M.D., Chicago, Director-General.
A Four Years' Survey of Medicine and Surgery in Industry. M. N. Newquist, M.D., Chicago.
The Value of an Organized Medical Service in an Industrial Establishment. Homer L. Ferguson, President, Newport News Shipbuilding and Dry Dock Company, Newport News, Va.
Papilloma and Carcinoma of the Bladder Among Dye Workers. George H. Gehrmann, M.D., Medical Director, E. I. du Pont de Nemours & Company, Wilmington, Del.
Back Injuries. Frederic J. Cotton, M.D., Boston.
Reconstruction Surgery. Sir Harold Gillies, C.B.E., F.R.C.S., London.

OPHTHALMOLOGY AND OTOLARYNGOLOGY

The committee in charge of the section on surgery of the eye, ear, nose, and throat has arranged a program of ophthalmological and otolaryngological clinics and demonstrations at the hospitals and medical schools. This appears in the following pages, and in addition programs for sessions on Tuesday, Wednesday, Thursday, and Friday afternoons in John Hancock Hall, located on St. James Avenue midway between the Statler and Copley-Plaza Hotels. At these sessions distinguished specialists will present papers on subjects of timely interest.

A symposium on "Diseases of the Œsophagus" will be presented on Thursday afternoon at 3:30 in the ballroom of the Copley-Plaza Hotel following the annual meeting. The program follows:

An X-ray Study on Lesions of the Œsophagus (statistical study with lantern slides). A. S. MACMILLAN.
Infection of the Œsophagus in Acute and Chronic Disease; Fibrosis of the Terminal Portion of the Œsophagus (Cardiospasm), Etiology and Treatment. HARRIS P. MOSHER.
The Surgical Approach to the Œsophagus. EDWARD D. CHURCHILL.

COMMUNITY HEALTH MEETING

Following its established custom and in recognition of its obligation to the public to provide authoritative information on modern surgery, better hospitals, and the prevention of disease, a community health meeting will be held on Wednesday evening, October 17, under the auspices of the American College of Surgeons in connection with the Clinical Congress. For this purpose the Boston Arena, which accommodates approximately 10,000 people, has been engaged. A program appropriate for the occasion has been prepared consisting of brief interesting talks on scientific medicine, health and hospitals. These talks will be supplemented by an interesting new sound motion picture on modern hospital care.

ROBERT B. GREENOUGH, M.D., Boston; President, American College of Surgeons, presiding.
The American College of Surgeons—Its Aims and Objects. FRANKLIN H. MARTIN, M.D., Chicago, Director-General.
A Century of Progress in Medicine. ALLEN B. KANAVEL, M.D., Chicago.
The Rôle of Experimental Medicine in Human Salvage. GEORGE W. CRILE, M.D., Cleveland.
Maternal Care in Approved Hospitals. MALCOLM T. MACEACHERN, M.D., Chicago.
Cancer—Its Prevention and Control. CLARENCE COOK LITTLE, Sc.D., New York.
Cancer—Its Curability. CHARLES A. DUKES, M.D., Oakland, Calif.
The Care of the Injured. FREDERIC A. BESLEY, M.D., Waukegan, Ill.
The Ache in Your Back. PHILIP H. KREUSCHER, M.D., Chicago.
Doctors, Hospitals, and Patients. ROBERT JOLLY, Houston, Texas.
Motion Picture—"Good Hospital Care."

ANNUAL HOSPITAL CONFERENCE

A highly practical and instructive four-day program has been prepared for the seventeenth annual hospital standardization conference during the Clinical Congress in Boston. The program appears in the following pages. Administrative, economic and educational topics will be presented by leaders in the hospital field including surgeons, trustees, administrators, nurses and research workers. These addresses will be supplemented by round table conferences and demonstrations in three of Boston's leading hospitals on Tuesday, Wednesday and Thursday afternoons.

At the opening session on Monday morning distinguished leaders in medical and hospital work will address the conference, the topics to be discussed tending to focus attention on present day problems related to hospital standardization and administration. Other sessions will be devoted to a discussion of major problems of concern to all hospitals—sterilization of surgical dressings, instruments and supplies, and standards for maternal care. Both subjects are now attracting widespread interest, and it is planned to present at these sessions the latest authentic facts pertaining thereto, expecting that such discussions will lead to a definite understanding as to the best standards to be adopted. At a special session on Tuesday evening in the Georgian Room of the Statler Hotel, a comprehensive analysis of the duties and responsibilities of the hospital trustees will be presented.

During recent years there has been a notable increased interest in hospital matters aroused through economic conditions. The problem of giving the patient the best scientific service possible at the lowest cost has seriously engaged the interest of all groups. Attention will be focused on this problem during the four-day conference. Physicians, trustees, administrators, nurses and others will have an opportunity at this meeting to discuss the many problems of mutual concern.

OTHER FEATURES OF THE PROGRAM

Surgical motion picture films, both sound and silent, will be exhibited daily in the Georgian Room at the Statler Hotel. Many new films will be shown. The showing of films demonstrating clinical features of interest has met with popular acceptance in recent years and will be continued at this session with an enlarged program.

Ether Day will be celebrated at the Massachusetts General Hospital on Tuesday with special exercises at 4 p.m. in the dome room of the old building of the hospital where ether was first administered for the production of surgical anæsthesia on October 16, 1846.

HEADQUARTERS

The Statler and Copley-Plaza Hotels will be utilized as headquarters for the Congress. At the former, the grand ballroom and adjoining assembly room together with other large rooms on the mezzanine floor have been reserved for the exclusive use of the Congress for registration and

clinic ticket bureaus, bulletin boards, technical exhibition, and executive offices. A scientific exhibit, which will be arranged by the local committee, is to be installed in the balcony of the ballroom. At the Copley-Plaza Hotel the grand ballroom will be utilized for evening scientific meetings, hospital conferences, and other large gatherings daily.

The technical exhibition will be located in the ballroom and adjoining assembly room at the Statler Hotel. The registration and clinic ticket desk, together with the information bureau, will be located in these rooms in which will also be found the bulletin boards on which the daily clinical programs will be posted each afternoon. The leading manufacturers of surgical instruments, electrosurgical and X-ray apparatus, operating room lights, tables, sterilizers, hospital apparatus and supplies of all kinds, ligatures, dressings, pharmaceuticals, and publishers of medical books will be represented in this exhibition.

ADVANCE REGISTRATION

The hospitals and medical schools of Boston afford accommodations for a large number of visiting surgeons, but to insure against overcrowding, attendance at the Congress will be limited to a number that can be comfortably accommodated at the clinics—the limit of attendance being based upon the result of a survey of the amphitheaters, operating rooms, and laboratories of the hospitals and medical schools to determine their capacity for visitors. It is expected, therefore, that those surgeons who wish to attend the Clinical Congress in Boston will register in advance by applying to the offices of the College in Chicago.

Admittance to all clinics and demonstrations will be controlled by means of special clinic tickets, which plan provides an efficient means for the distribution of the visiting surgeons among the several clinics and insures against overcrowding, as the number of tickets issued for any clinic will be limited to the capacity of the room in which that clinic will be given.

A registration fee of $5.00 is required of each surgeon attending the annual Clinical Congress, such fees providing the funds with which to meet the expenses of the meeting. To each surgeon registering in advance a formal receipt for the registration fee is issued, which receipt is to be exchanged for a general admission card upon his registration at headquarters. This card, which is non-transferable, must be presented in order to secure clinic tickets and admission to the evening meetings.

BOSTON HOTELS AND RATES

Boston hotels will provide ample facilities and there should be no difficulty in securing first-class accommodations. It is advisable, however, for those who expect to attend the Clinical Congress to reserve their accommodations as far in advance as possible. In addition to the headquarters hotels, the Statler and Copley-Plaza, there are a number of first-class hotels within walking distance of headquarters. The following list of hotels with their rates has been prepared by the local committee:

	Minimum Rates with bath	
	Single	Double
Bellevue, 21 Beacon Street	$3.00	$5.00
Bradford, 275 Tremont Street	2.50	3.50
Braemore, 464 Commonwealth Avenue	3.00	4.00
Brunswick, 520 Boylston Street	2.50	4.00
Buckminster, 645 Beacon Street	2.00	3.50
Canterbury, 14 Charlesgate West	2.50	3.00
Charlesgate, 535 Beacon Street		4.00
Copley-Plaza, 138 St. James Avenue	4.00	6.00
Fensgate, 534 Beacon Street	2.50	3.50
Graylyn, 20 Charlesgate West		5.00
Hemenway, 91 Westland Avenue	2.50	3.50
Kenmore, 490 Commonwealth Avenue	3.00	4.50
Lenox, Exeter Street	2.50	3.50
Lincolnshire, 20 Charles Street	3.00	4.50
Manger, North Station	2.50	3.50
Parker House, 60 School Street	3.00	4.50
Puritan, 390 Commonwealth Avenue	3.50	5.00
Ritz-Carlton, 15 Arlington Street	4.00	7.00
Sheraton, 91 Bay State Road	3.00	4.00
Somerset, 400 Commonwealth Avenue	3.00	3.50
Statler, Park Square	3.50	5.00
Touraine, 62 Boylston Street	3.00	5.00
Vendome, 160 Commonwealth Avenue	2.50	4.00
Victoria, 271 Dartmouth Street	3.00	5.00
Westminster, 124 St. James Avenue	2.50	3.50

REDUCED RAILWAY FARES

The railways of the United States and Canada have authorized reduced fares on account of the Boston session of the Clinical Congress so that the total fare for the round trip will be one and one-third the ordinary first-class one-way fare. To take advantage of the reduced rates it is necessary to pay the full one-way fare to Boston, procuring from the ticket agent when purchasing ticket, a "convention certificate," which certificate is to be presented at headquarters for the signature of the general manager of the Clinical Congress and the visé of a special agent of the railways. Upon presentation of the viséd certificate to the ticket agent in Boston not later than October 23, a ticket for the return journey by the same route as traveled to Boston may be purchased at one-third the one-way fare.

In the eastern, central, and southern states and eastern provinces of Canada tickets may be pur-

chased between October 11 and 16; in other sections of the United States and Canada at earlier dates. The return journey must be completed within thirty days from date of sale of ticket to Boston.

The reduction in fares does not apply to Pullman fares nor to extra fares charged for passage on certain trains. Local railroad ticket agents will supply detailed information with regard to dates of sale, routes, etc. Stop-overs may be had within certain limits.

Full fare must be paid from starting point to Boston, and it is essential that a "convention certificate" be obtained from the agent when the ticket is purchased. These certificates are to be signed by the general manager of the Clinical Congress and viséd by a special railroad agent at Clinical Congress headquarters on or before October 19. No reduction in railroad fares can be secured except in compliance with the regulations outlined and within the dates specified. It is important to note that the return trip must be made by the same route as used in going to Boston, that the certificate must be viséd at headquarters during the meeting, and return ticket purchased not later than October 23.

In the western and southwestern states, including the Pacific coast states and the western provinces of Canada, the railroads have authorized the sale of round trip tickets to Chicago at very low rates on account of A Century of Progress Exposition, so that persons from the west traveling through Chicago to Boston will find it to their advantage to buy round trip tickets to Chicago at the low rates in effect on account of the Exposition. Under this plan it will be necessary to purchase tickets to Boston from Chicago taking advantage of the "convention certificate" plan outlined above. Ticket agents should be consulted with regard to special rates.

SCIENTIFIC EXHIBITS

AT HEADQUARTERS, STATLER HOTEL

FRACTURES. Demonstrating methods of treating fractures, under the auspices of the New England Fracture Committee of the American College of Surgeons.

PLASTIC SURGERY. An exhibit of models, photographs, and diagrams, illustrating the different methods employed in plastic surgery and the results.

TRAUMATIC SURGERY. Diagrams, photographs, and charts.

ORTHOPEDIC SURGERY. An exhibit of splints and other forms of orthopedic apparatus, together with charts and photographs.

MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH. An exhibit illustrating the activities of this department.

CANCER. An exhibit from the Palmer Memorial Hospital, Collis P. Huntington Memorial Hospital, and the Pondville State Cancer Hospital. Lantern slides, charts, and photographs illustrating cancer of the various organs of the body; the diagnosis and the results obtained by different forms of treatment. Also, an exhibit of specimens of cancer from many parts of the body.

OPHTHALMOLOGY. Charts and photographs illustrating melanotic sarcoma and other conditions of the eye. Heredity of immune reactions; hereditary blindness; pedigree of blindness.

PATHOLOGY. The specimens removed at operations from the various hospitals in the morning will be collected and placed on exhibition in artificially cooled showcases in the afternoon, in a room adjoining the Georgian Room. At 5 p.m. these specimens will be demonstrated in the Georgian Room by a projectoscope, the microscopic sections shown, and the cases discussed.

AT HOSPITALS AND MEDICAL INSTITUTIONS

HARVARD DENTAL SCHOOL. An exhibit of models, photographs, and diagrams showing the restoration of extensive defects and deformities of the face and jaws by plastic surgery and dental prosthesis, including cases of soldiers wounded in the World War.

BOSTON MEDICAL LIBRARY. Exhibit of historical books on surgery and anatomy, and surgical medals. Historical pageant illustrating the development of surgery, Wednesday, October 17, John Ware Hall, 4 p.m.; presented by the students of Tufts College Medical School under the direction of Professor B. Spector. Exhibition of works of art by Massachusetts physicians under auspices of the Physicians Art Society.

MASSACHUSETTS GENERAL HOSPITAL. Daily, at noon, an exhibit in the Ether Dome relative to the first public demonstration of ether anæsthesia including a showing of the motion picture "The First Public Demonstration of Ether Anæsthesia." Also the motion picture film, "Fractures in Transportation."

MASSACHUSETTS CHARITABLE EYE AND EAR INFIRMARY. Anatomical specimens and œsophageal instruments.

HARVARD MEDICAL SCHOOL, Warren Museum. Anatomy, anatomical specimens; pathology, pathological specimens.

OPHTHALMOLOGY AND OTOLARYNGOLOGY—SCIENTIFIC SESSIONS

Tuesday—John Hancock Hall, 2—Ophthalmology

JOHN M. WHEELER, New York. Plastic ophthalmic surgery. Discussion opened by W. B. LANCASTER.

JONAS S. FRIEDENWALD, Baltimore. Slit lamp ophthalmoscopy. Discussion opened by J. H. WAITE.

CLARENCE KING, Cincinnati. Tuberculin in the treatment of ocular tuberculosis. Discussion opened by MERRILL KING.

RAFAEL SILVA, Mexico City. Subject to be announced.

Wednesday—John Hancock Hall, 2—Otolaryngology

THOMAS E. CARMODY, Denver. Congenital deformities of the face and neck. Discussion opened by V. H. KAZANJIAN.

LOUIS H. CLERF, Philadelphia. Peroral endoscopy in otolaryngological practice.

SAMUEL J. CROWE, Baltimore. Ménière's symptom complex. Discussion opened by PHILIP MELTZER.

JOHN R. PAGE, New York. Acute infections of the middle ear and mastoid.

O. JASON DIXON, Kansas City. A departure in the management of acute mastoid disease or the advantages of conservative treatment in acute mastoid disease. Discussion opened by LYMAN RICHARDS.

GEORGE M. COATES, Philadelphia. Diagnosis of chronic infection of the tonsils in relation to indications for operation in cases of chronic focal infection.

WILLIAM V. MULLIN, Cleveland. Present status of infection of the upper respiratory tract in its relation to focal infection. Discussion opened by H. ARCHIBALD NISSEN.

EDWARD ZEIGELMAN, San Francisco. The clinical and surgical significance of the component cellular characteristics of the temporal bone, based upon a series of 100 cadaver and autopsy observations, lantern slide demonstration.

Thursday—John Hancock Hall, 2—Ophthalmology

LUTHER C. PETER, Philadelphia. The technique of orthoptic training in strabismus. Discussion opened by DAVID MILLS.

HARRY S. GRADLE, Chicago. Recent therapeutic procedures. Discussion opened by ALLEN GREENWOOD.

WILLIAM L. BENEDICT, Rochester, Minn. Subject to be announced. Discussion by W. MILLBROOK LOWEL.

C. N. SPRATT, Minneapolis. Closure of the cataract incision (motion pictures).

Ballroom, Copley-Plaza Hotel—3:30—Otolaryngology

A. S. MACMILLAN. An X-ray Study on Lesions of the Œsophagus (statistical study with lantern slides).

HARRIS P. MOSHER. Infection of the Œsophagus in Acute and Chronic Disease; Fibrosis of the Terminal Portion (Cardiospasm), Etiology and Treatment.

EDWARD D. CHURCHILL. The Surgical Approach to the Œsophagus.

Friday—John Hancock Hall, 2—Otolaryngology

SAMUEL J. KOPETZKY, New York. Recent developments in the diagnosis of meningitis.

WELLS P. EAGLETON, Newark, N. J. Meningitis—result of disease of the petrous apex and sphenoidal basis.

MARVIN F. JONES, New York. Pathways of approach to the petrous pyramid. Discussion by HARRY P. CAHILL.

WILLIAM MITHOEFER, Cincinnati. When and how shall a nasal sinus inflammation be treated nonsurgically?

EDWARD C. SEWELL, San Francisco. Operative treatment of sinusitis, external approach. Discussion opened by CHARLES T. PORTER.

GABRIEL TUCKER, Philadelphia. Cancer of the larynx.

HENRY B. ORTON, Newark, N. J. Cancer of the laryngopharynx. Discussion opened by LEROY A. SCHALL.

PRELIMINARY PROGRAM FOR EVENING MEETINGS

Presidential Meeting—Monday—October 15, 8:15 p.m.

Address of Welcome: ARTHUR W. ALLEN, M.D., Boston, Chairman, Committee on Arrangements

Introduction of Foreign Guests: FRANKLIN H. MARTIN, M.D., Chicago, Director-General

Address of Retiring President: WILLIAM D. HAGGARD, M.D., Nashville, Tenn.

Inauguration of Officers

Inaugural Address. ROBERT B. GREENOUGH, M.D., Boston

John B. Murphy Oration in Surgery: Principles of Gastric Surgery. DONALD C. BALFOUR, M.D., Rochester, Minn.

Tuesday—October 16, 8:15 p.m.

Living Grafts of Thyroid and Parathyroid Glands. HARVEY B. STONE, M.D., Baltimore, with the collaboration of JAMES C. OWINGS, M.D., and GEORGE O. GUY, M.D., Baltimore

Endocrine Mechanisms in Certain Functional Gynecological Disorders. EMIL NOVAK, M.D., Baltimore

Fracture Oration: The Unsolved Fracture. KELLOGG SPEED, M.D., Chicago

The Giant-Cell Tumor of Bone as a Clinical Entity. HARRY PLATT, M.S., F.R.C.S., Manchester, England.

Wednesday—October 17, 8:15 p.m.

Hydrocephalus and Spina Bifida. WILDER PENFIELD, M.D., Montreal

Sterility with Special Reference to Surgical Possibilities. BETHEL SOLOMONS, M.D., F.R.C.P.I., Dublin, Ireland

Diverticulosis and Diverticulitis. IRVIN ABELL, M.D., Louisville

Thursday—October 18, 8:15 p.m.

Symposium on Treatment of Infections:

Infections of Clean Operative Wounds. FRANK L. MELENEY, M.D., New York

Infections of the Lip and Face. FREDERICK A. COLLER, M.D., Ann Arbor, Mich.

Phagedenic Ulcer; its Recognition and Treatment. EMILE HOLMAN, M.D., San Francisco

The Repairs of Defects Resulting from Full Thickness Loss of Skin from Burns. JAMES B. BROWN, M.D., St. Louis

Convocation—Friday—October 19, 8:15 p.m.

Invocation. REV. CHARLES WESLEY BURNS, D.D., LL.D., Boston

Presentation of Candidates for Fellowship. FRANKLIN H. MARTIN, M.D., Chicago, Director-General

Conferring of Fellowships. The President

Conferring of Honorary Fellowships. The President

Presidential Address. ROBERT B. GREENOUGH, M.D., Boston

Fellowship Address

ANNUAL HOSPITAL STANDARDIZATION CONFERENCE

Monday, 9:30–12:30—Ballroom, Copley-Plaza Hotel

Chairman's Address. WILLIAM D. HAGGARD, M.D., Nashville, Tenn.

Presentation of Seventeenth Annual Hospital Standardization Report. FRANKLIN H. MARTIN, M.D., Chicago.

Guiding Fundamental Principles for Prepayment of Hospital and Medical Services. CHARLES A. DUKES, M.D., Oakland, Calif.

The Development of Periodic Prepayment Plans for Hospital Care in England. SYDNEY LAMB, Liverpool, England.

The Hospital in Retrospect and Introspect. REV. ALPHONSE M. SCHWITALLA, S.J., Ph.D., St. Louis.

Future Trends in Hospital Management and Service. BERT W. CALDWELL, M.D., Chicago.

The Proper Interpretation of Hospital Service. NEWTON E. DAVIS, D.D., Columbus, Ohio.

What the Hospital Can Do for the Younger Surgeon. WITTEN B. RUSS, M.D., San Antonio, Texas.

Principles Governing Relation of Radiologists to Hospitals, ARTHUR C. CHRISTIE, M.D., Washington, D. C.

Monday, 2:00–5:00—Ballroom, Copley-Plaza Hotel

Standards for Obstetrical Service in Hospitals.

GEORGE W. KOSMAK, M.D., New York, presiding.

A Study of Obstetric Complications in the Woman's Hospital to Establish Proper Standardization for Statistical Purposes. GEORGE GRAY WARD, M.D., BYRON H. GOFF, M.D., and ALBERT H. ALDRIDGE, M.D., New York.

Regulations and Control of Obstetrical Practices in Institutions by Nonstaff Physicians. SAMUEL A. COSGROVE, M.D., Jersey City, N. J.

Minimum Standards of the American College of Surgeons for the Care of Obstetrical Patients in General Hospitals. ROBERT A. JOHNSTON, M.D., Houston, Texas.

General discussion led by JAMES RAGLAN MILLER, M.D., Hartford, Conn.

Tuesday, 9:30–12:30—Ballroom, Copley-Plaza Hotel

Sterilization of Dressings, Instruments, and Supplies.

G. HARVEY AGNEW, M.D., Toronto, Ont., presiding.

Observations on Sterilization of Dressings with Specific Reference to Sterilizing Chamber Temperatures and Their Relation to Sterilizer Chart Temperatures and Cultures. SAMUEL R. D. HEWITT, M.D., St. John, N. B.

A Scientific Analysis of Steam in Sterilizing, Showing How Precision Methods May Be Substituted for the Indefinite Methods now in Vogue. WEEDEN B. UNDERWOOD, Erie, Pa.

Checking and Controlling Postoperative Infections. HAROLD L. FOSS, M.D., Danville, Pa.

The Fundamental Principles Underlying the Mechanics and Technique of Sterilization. HURLEY T. WYATT, M.S., Madison, Wis.

General discussion opened by CLAUDE W. MUNGER, M.D., Valhalla, N. Y.

Tuesday, 2:00–4:00—Massachusetts General Hospital

ROBERT JOLLY, Houston, Texas, presiding.

Demonstrations and round table discussions in hospital standardization and administration, conducted by GEORGE H. BIGELOW, M.D., Director, and heads of departments.

Tuesday, 8:00–10:00 p. m.—Georgian Room, Statler Hotel

Special Session for Hospital Trustees

C. P. CURTIS, Boston, presiding.

How I View my Responsibility as a Hospital Trustee. IDA M. CANNON, Boston.

How I Discharge my Duties as a Hospital Trustee. FULLER BARNES, Bristol, Conn.

General discussion led by JOSEPH C. DOANE, M.D., Philadelphia.

Motion Picture—"Good Hospital Care" (sound).

Wednesday, 9:30–12:30—Ballroom, Copley-Plaza Hotel

Joint Session with Association of Record Librarians of North America. JAMES T. NIX, M.D., New Orleans, presiding.

The Use of the National Nomenclature. H. B. LOGIE, M.D., New York.

Basic Training for a Record Librarian. JESSIE N. HARNED, Rochester, N. Y.

The Organization and Management of the Medical Records Department in a Sisters' Hospital. SISTER M. PATRICIA, Duluth, Minn.

Round table conference—problems concerned with clinical records, with special discussion of uses of clinical records. Conducted by ALLAN CRAIG, M.D., Torrington, Conn.

Wednesday, 2:30–5:00—St. Elizabeth's Hospital

MALCOLM T. MACEACHERN, M.D., Chicago, presiding.

Demonstrations and round table discussions in hospital standardization and administration. Conducted by REV. THOMAS J. BRENNAN, Superintendent, and heads of departments.

Thursday, 9:30–12:00—Ballroom, Copley-Plaza Hotel

Round table conference. Conducted by ROBERT JOLLY, Houston, assisted by MALCOLM T. MACEACHERN, M.D., Chicago.

This will be a clearing house for all questions arising out of the deliberations of the previous sessions and problems in the minds of any present, in addition to a special program of fifty important hospital questions.

Thursday, 2:30–5:00—Beth Israel Hospital

ROBERT JOLLY, Houston, Texas, presiding.

Demonstrations and round table discussions in hospital standardization and administration. Conducted by CHARLES F. WILINSKY, M.D., Director, and heads of departments.

PRELIMINARY CLINICAL PROGRAM

GENERAL SURGERY, GYNECOLOGY, OBSTETRICS, ORTHOPEDICS, UROLOGY, PROCTOLOGY, SURGICAL PATHOLOGY, ETC.

MASSACHUSETTS GENERAL HOSPITAL

Monday

Staff—2. Dry clinic. A. W. ALLEN: Bleeding peptic ulcer. JOHN STEWART: Water balance in the surgical patient. C. M. JONES: Nutritional œdema. L. S. MCKITTRICK: Cancer of rectum. E. L. YOUNG, JR.: Cancer of colon. J. V. MEIGS and F. W. HOYT: Rupture of Graafian follicle and corpus luteum. R. H. WALLACE: Treatment of burns.

W. J. MIXTER, JOHN HODGSON and associates—2. Neurosurgical clinic.

V. H. KAZANJIAN, E. M. DALAND and associates—2. Plastic surgery clinic.

T. R. GOETHALS and associates—4. Obstetrical clinic.

Tuesday

Staff—9. Operative clinics. General surgical, genito-urinary, and thyroid services.

H. C. MARBLE and T. W. HARMER—2. Surgery of the hand.

GEORGE HOLMES, A. O. HAMPTON and associates—2. Symposium on the roentgen ray.

E. D. CHURCHILL and associates—2. Surgical research laboratories, demonstration of specimens and discussions.

M. N. SMITH-PETERSEN and associates—2. Orthopedic clinic.

Ether Day exercises—4.

Wednesday

Staff—9. Operative clinics, general surgical, fracture and circulatory services.

Staff—2. Dry clinic. D. KING: Postoperative pulmonary complications. H. BRADSHAW: Methods in anæsthesia. H. SPRAGUE: Surgery in cardiac patients. L. S. MCKITTRICK and R. H. MILLER: Ulcerative colitis. E. D. CHURCHILL: Cardiolysis. E. B. BENEDICT: Gastroscopy. R. H. MILLER: Osteomyelitis.

J. V. MEIGS, F. ALBRIGHT and associates—2. Ovarian dysfunction clinic.

A. W. ALLEN, G. A. LELAND and associates—2. Fracture clinic.

E. P. HAYDEN and associates—2. Proctology.

Thursday

Staff—9. Operative clinics, general surgical and thoracic services.

E. A. CODMAN and associates—9. Symposium on lesions of the shoulder.

T. B. MALLORY—12. Clinical pathological conference.

E. D. CHURCHILL, W. WHITTEMORE and associates—2. Thoracic surgery clinic.

A. W. ALLEN and associates—2. Circulatory diseases clinic.

C. C. SIMMONS and associates—2. Tumor clinic; cancer symposium.

Friday

Staff—9. Operative clinics, general surgical and orthopedic services, neurological operations; plastic surgery.

Staff—2. Dry clinic. C. LYONS: Symbiotic infections. B. VINCENT and A. V. BOCK: Surgery of spleen. A. W. ALLEN: Regional ileitis. R. H. MILLER: Tuberculosis of the lymphatic system. R. LINTON: Perforation of the cecum complicating carcinoma of colon. R. H. SMITHWICK: Gall-bladder disease, correlation of operative and X-ray findings. OLIVER COPE: Virilism syndrome. H. ROGERS: Pilonidal sinus.

J. H. MEANS, A. W. ALLEN, E. D. CHURCHILL, R. H. MILLER, E. L. YOUNG, JR. and associates—2. Diseases of the thyroid and parathyroid.

J. D. BARNEY and associates—2. Genito-urinary surgery.

CARNEY HOSPITAL

Monday

HAROLD G. LEE—3. Operative treatment for certain types of low back pain, demonstration of cases.

R. J. HEFFERNAN—3:30. End-results following interposition for uterine prolapse.

Tuesday

LOUIS E. PHANEUF—9:30. Vaginal hysterectomy for procidentia; repair of third degree laceration of perineum.

W. R. MACAUSLAND—9:30. Arthroplasty of hip, elbow or knee.

LOUIS E. PHANEUF—2:30. End-results in cervical Cæsarean section, lantern slide demonstration.

ROGER C. GRAVES—3:15. Transurethral resection of the prostate; selection of cases, pre-operative preparation, operative technique, after-care of patient.

Wednesday

F. B. LUND, D. F. MAHONEY, A. MCK. FRASER, W. E. BROWNE and F. J. NASH—9:30. General surgical operations.

W. E. BROWNE—2:45. Demonstration of end-results following treatment for injuries of musculospiral nerve, posterior interosseous branch, median nerve in forearm, ulnar nerve injuries at elbow, in mid forearm, at wrist.

A. LEO BRETT—3:30. Demonstration of patient following operations for relief of paralysis resulting from myeloma with destruction of tenth dorsal vertebra; moving picture demonstration of operative technique in spinal cord tumors.

Thursday

LOUIS E. PHANEUF—9:30. Hysterectomy for fibroids.

R. J. HEFFERNAN—10:30. Vaginal operation for procidentia uteri; vaginal plastic operation for lacerations.

LOUIS E. PHANEUF—2:45. Management of placenta prævia, lantern slide demonstration.

Friday

F. B. LUND, D. F. MAHONEY, A. MCK. FRASER, W. E. BROWNE and F. J. NASH—9:30. General surgical operations.

W. E. BROWNE—2:45. Demonstration of end-results following full thickness grafts for contractures in various parts of forearm and hand. Method of preparation of splints used and various types of splints used in this work.

BOSTON CITY HOSPITAL

Monday

Staff—2. Dry clinic. J. J. REGAN, S. WEISS, and D. MUNRO: The eye in arteriosclerosis, hypertension and tumor. G. K. COONSE: Treatment of shock. J. RESNIK and M. RITVO: Pellegrini-Steida's disease, diagnosis and treatment. O. J. HERMANN and E. PARKER, JR.: Synovioma of knee. F. A. SLOWICK: Septic hips.

Tuesday

DAVID D. SCANNELL, SOMERS FRASER, THOMAS W. WICKHAM, and JOHN A. SETH—9. General surgical dry clinic.

First surgical service—9. General surgical operative clinic. HORACE BINNEY: Thoracoplasty for unilateral phthisis; phrenicectomy for unilateral phthisis. JAMES J. HEPBURN: Repair of ventral hernia; gastric ulcer. GEORGE W. PAPEN: Chronic empyema; cholecystitis.

Fifth surgical service—2. Dry clinic. IRVING J. WALKER: Some surgical aspects of jaundice—hyperparathyroidism, end-results; repair of common duct; chondrosarcoma of humerus, end-results; carcinoma of stomach, end-result; ligation of common carotid artery, end-result. FRANCIS F. HENDERSON: Carcinoma of lung; pancreatitis, review of sixty cases. AUGUSTUS RILEY: Prostate and vesicles as foci for retroperitoneal infection; kidney resections; demonstration of cases. CHARLES C. LUND: Peripheral arterial embolism, results of operative treatment in fifteen cases. E. EVERETT O'NEIL: Breast tumors, clinical versus X-ray diagnosis. WILLIAM A. WHITE: Subject to be announced.

ROBERT M. GREEN, JOHN T. WILLIAMS, FREDERICK L. GOOD, JOSEPH P. COHEN, and associates—2. Gynecological and obstetrical dry clinic: Treatment of miscarriages; puerperal sepsis; pelvic inflammation.

Wednesday

IRVING J. WALKER, FRANCIS F. HENDERSON, CHARLES C. LUND, E. EVERETT O'NEIL, and WILLIAM A. WHITE—9. General surgery, operative clinic.

Bone and joint service—9. Dry clinic. OTTO J. HERMANN: Boston City Hospital bone and joint service. THOMAS H. PETERSON: Colles' fracture therapy; Soutter traction in unreduced fractures of the forearm and old shoulder dislocations. GEORGE K. COONSE: Fracture of the olecranon, new operative repair. OTTO J. HERMANN: Recurrent shoulder dislocations repaired by the Nicola method, end-results, discussion. WILLIAM F. COTTING and MARK H. ROGERS: Subdeltoid bursitis. MARK H. ROGERS: Rupture of supraspinatus tendon, discussion. JOSEPH H. SHORTELL: Spinal fracture, therapy. RUSSELL F. SULLIVAN: Spinal fusions. OTTO J. HERMANN: Compound fracture therapy. FRANK W. MARVIN: Anæsthesia in fractures.

First surgical service—2. Dry clinic. NEWTON C. BROWDER: Results of treatment of Colles' fracture; modern splinting methods in fracture therapy. JAMES J. HEPBURN: Results in treatment of peptic ulcer; giant-cell sarcoma of bone; treatment of ventral hernia. HORACE BINNEY: Methods and results in treatment of acute empyema, lung abscess, bronchiectasis, pulmonary tuberculosis. GEORGE W. PAPEN: Methods and results in treatment of chronic empyema.

Sixth surgical service—2. Dry clinic. JAMES W. SEVER: Separation of femoral epiphysis. MARK H. ROGERS: Ankylosed hips. OTTO J. HERMANN: Treatment of intracapsular fractures of neck of femur, demonstration of cases of recent fractures and ununited fractures. FREDERIC J. COTTON: Pelvic fractures. JOSEPH H. SHORTELL: Bone grafting.

ROBERT M. GREEN, JOHN B. WILLIAMS, FREDERICK L. GOOD, JOSEPH P. COHEN, and associates—9. Gynecological and obstetrical operations.

Thursday

OTTO J. HERMANN, JOSEPH H. SHORTELL, WILLIAM F. COTTING, RUSSELL F. SULLIVAN, THOMAS H. PETERSON, and G. KENNETH COONSE—9. Operative bone and joint clinic. Ward rounds, demonstration of fracture apparatus, etc.

Second surgical service—9. ROBERT C. COCHRANE: Total thyroidectomy for congestive failure and angina; parathyroid tumors. WILLIAM R. MORRISON: One hundred perforated ulcers of the stomach and duodenum from the Boston City Hospital; stomach surgery, motion picture demonstration; demonstration of following cases—total removal of stomach for cancer with anastomosis of the jejunum to the œsophagus, hour-glass deformity of the stomach, cholecystgastrotomy formed by nature. THOMAS K. RICHARDS: Knee-joint pathology. JOHN J. LUCY: Recurrent intussusception caused by intestinal tumor; carcinoma of the sigmoid. RICHARD I. SMITH: Pancreatitis. HERBERT H. HOWARD: End-results of bilateral renal tuberculosis; importance of postoperative treatment of prostatectomized patient.

Fourth surgical service—2. Dry clinic. ARTHUR R. KIMPTON: Civilian gas gangrene; tetanus; use of amniotic liquid concentrate; cavernous hæmangioma of neck; catheter in common bile duct since 1926; ununited fractures. EDWARD HARDING: Demonstration of cases. JOSEPH H. BURNETT: Colles' fracture therapy. H. A. BOUVÉ: Acute traumatic abdomen.

Sixth surgical service—2. Bone and joint dry clinic. WILLIAM F. COTTING: Gonorrhœal arthritis of the knee. RUSSELL F. SULLIVAN: Hallux valgus therapy. OTTO J. HERMANN: Fractures of the os calcis therapy, discussion. JOSEPH H. SHORTELL: Bone tumors. FREDERICK W. O'BRIEN: Pre- and postoperative X-ray therapy in malignant tumors of the bone. THOMAS H. PETERSON: "Fender" fractures.

ROBERT M. GREEN, JOHN B. WILLIAMS, FREDERICK L. GOOD, JOSEPH P. COHEN, and associates—9. Obstetrical and gynecological operations.

Friday

ARTHUR R. KIMPTON, ROBERT C. COCHRANE, WILLIAM R. MORRISON, STEPHEN P. MALLETT, and V. H. KAZANJIAN—9. General surgery, operative clinic.

Staff—9. Gynecological and obstetrical operations.

Staff—2. Dry clinic. J. J. REGAN and W. B. CASTLE: The eye in anæmic patients. STEPHEN P. MALLETT: Fractures of the jaw. WILLIAM R. MORRISON: Visualization of arteries and veins for diagnosis and operation of aneurysm; ligation of the first part of right subclavian artery and subsequent ligation of innominate artery for arteriovenous aneurysm of internal jugular vein and subclavian artery. OTTO J. HERMANN and WILLIAM R. MORRISON: Chronic subluxation of sternal end of clavicle. STEPHEN J. MADDOCK: The Baer maggot treatment of chronic osteomyelitis.

Physiotherapy service—9. Dry clinic. JOSEPH RESNIK: Electrodiagnosis. JOSEPH RESNIK, GIRDIE W. DICKINSON, ARTHUR J. COLE, WALDO W. ROBBINS, and SIDNEY M. SIMONS: Demonstration of cases and treatment.

CHILDREN'S HOSPITAL

Monday

W. E. LADD and associates—2. Fractures in children. W. E. LADD: Elbow fractures. T. H. LANMAN: Fractures of the femur. P. J. MAHONEY: Fractures of both bones of the forearm.

Tuesday

F. R. OBER and associates—9. Orthopedic operations.
W. E. LADD—9:30. Plastic repair of harelip and cleft palate, demonstration of cases, motion picture demonstration.
THOMAS H. LANMAN—10. Acute osteomyelitis in infancy and childhood.
PATRICK J. MAHONEY—10:30. The use of various types of skin grafts in children's surgery.
HENRY HUDSON, JR.—11. Acute appendicitis in childhood; Meckel's diverticulum.
Staff—2. Operative clinic, surgery in infants and children.
Staff—2. Orthopedic clinic. A. T. LEGG: Early treatment and the prevention of deformities in poliomyelitis. F. R. OBER: Shoulder operations. J. W. SEVER: Stabilization of the ankle joint. M. KATZEFF: Tendon transplants. A. T. LEGG: Abductor limp.

Wednesday

F. R. OBER and associates—9. Orthopedic clinic at Peabody Home.
Staff—9:30. Operative clinic.
W. E. LADD—2. Congenital hypertrophic pyloric stenosis; intussusception, diagnosis and treatment.
DONALD W. MACCOLLUM—2:30. Treatment of undescended testes, end-results over a 34 year period.
THOMAS H. LANMAN—3. Chronic pulmonary suppuration, demonstration of cases.
HENRY HUDSON, JR.—3:15. Empyema in childhood, its treatment.
SIDNEY FARBER—3:30. Surgical pathology of malignant tumors in infancy and childhood, followed by demonstration of pathological specimens in department of pathology.
EDWARD C. VOGT—3:45. Roentgenological studies of unusual bone tumors in infancy and childhood.

Thursday

F. R. OBER and associates—9. Orthopedic operations.
W. E. LADD—9:30. Intestinal atresia, diagnosis and treatment, demonstration of cases, lantern slides.
PATRICK J. MAHONEY—10. Types of tracheo-œsophageal fistulæ; differential diagnosis and operative treatment; congenital and acquired œsophageal stricture, demonstration of methods of dilatation.
W. E. LADD—10:30. Atresia of the bile ducts, diagnosis and treatment; choleductus cyst, diagnosis and treatment.
THOMAS H. LANMAN—11. Ureteral transplantation for extrophy of the bladder, demonstration of treated cases.
Staff—2. Operative clinic, surgery in infants and children.
Staff—2. Orthopedic dry clinic. A. H. BREWSTER: Claw feet. F. H. MORRIS: Torticollis, mastoid approach. H. FITZSIMMONS: Discussion. F. R. OBER: Semilunar cartilage. H. FITZSIMMONS: Osteoclasis. R. H. MORRIS: Club feet.

Friday

Staff—9. Orthopedic clinic. S. M. FITCHET: Cleidocranial dysostosis. F. R. OBER: Shelf operations; Sprengel's deformity. S. M. FITCHET: Flexion deformity of the hips. A. T. LEGG: Coxa plana. J. W. SEVER: Obstetrical paralysis.
Staff—9:30. Operative clinic, surgery in infants and children.
W. E. LADD—2. Ulcerative colitis in childhood—diagnosis and treatment; demonstration of cases, lantern slide demonstration.
PATRICK J. MAHONEY—2:30. Treatment of fresh burns.
DONALD W. MACCOLLUM—2:45. Treatment of hæmangioma by endothermy, demonstration of cases.
W. E. LADD—3. Surgical significance of pyuria in infancy and childhood, demonstration of cases, lantern slide demonstration.
T. H. LANMAN—3:30. Malignant bladder tumors in childhood.

CAMBRIDGE CITY HOSPITAL

Tuesday

H. H. GERMAIN, D. F. MAHONEY, E. J. O'BRIEN, E. D'ERRICO, and E. DOWNEY—9. Dry clinic. H. H. GERMAIN: Results in surgery of the shoulder, nerve suture; partial rupture of posterior cord of brachial plexus; fascial graft for recurrent dislocation of shoulder; arthroplasty of shoulder; arthroplasty for ankylosis of temporomaxillary articulation; skin graft for extensive burns. D. F. MAHONEY: End-results in fracture of pelvis and humerus. E. J. O'BRIEN: End-results in transurethral resection of the prostate; massive diverticulum of the bladder in a child 2½ years old. E. J. O'BRIEN: X-ray films of injuries to the head and spine. B. A. GODVIN and WALDO ROBBINS: Orthopedic clinic; end-results in fracture of hip. E. D'ERRICO: Results in injection treatment of varicose veins, moving picture demonstration. E. DOWNEY: Injection treatment of hæmorrhoids, methods used and demonstration of cases.

Wednesday

H. H. GERMAIN—9. Surgical operations. Demonstration: Nussbaum operation for leg ulcer (2 cases); tumor of the parotid (2 cases).
Staff—9. Dry clinic. MAXWELL MACDONALD: Encephalography as an aid to diagnosis in cerebral lesions. F. G. MINITER and T. E. DINAN: Results of accessory sinus operations, demonstration of cases. R. D. YOUNG: Cæsarean section. F. J. LYNCH: To be announced. J. J. MURPHY: Treatment problems of burns in general hospital. J. W. ROCKETT: Oral surgery operations. ARTHUR SARGENT and WILLIAM LANNIGAN: Orthopedic and fracture clinic. F. O. O'BRIEN: Traumatic spine and head injuries, demonstration of X-ray films. J. W. ROCKETT and F. MCLEAN: Fractures of lower and upper jaw. M. SHEA: Arthroplasty of lower jaw.
E. J. O'BRIEN and L. ROCKWELL—10:30. General surgical operations.
E. D'ERRICO—2. Acute torsion of great omentum; appendicitis complicating pregnancy.

Thursday

D. F. MAHONEY—9. General surgical operations.
J. J. MURPHY—10:30. General surgical operations; problem of rupture of urethra, fracture of pelvis and fracture of femur.
F. O. O'BRIEN—11. Traumatic spine and head injuries, demonstration of X-ray films.

MASSACHUSETTS MEMORIAL HOSPITAL

Daily

Staff—9. Operative clinics.
Staff—2. Dry clinics.

BETH ISRAEL HOSPITAL

Monday

Staff—2:30. Dry clinic. JOHN SEARS: Prophylactic vein ligation against embolism from phlebitis of the internal saphenous vein. MAXWELL BLOOMBERG: The prevention of scar tissue by the use of baudruche, experimental and clinical experiences, demonstration of cases. WALTER S. LEVENSON: Intraperitoneal adhesions. A. LOUIS HERMANSON: Transfusions during active bleeding from peptic ulcer. AARON THURMAN: Surgical treatment of cholecystitis. JOSEPH MEZER: Subacute pancreatitis. BORIS RAPAPORT: Comparison of postoperative complications following spinal and general anæsthesia.

Tuesday

Staff—9. Symposium on total thyroidectomy for chronic heart disease and angina pectoris. HERRMAN L. BLUMGART: Rationale of total thyroidectomy in chronic heart disease. JOSEPH RISEMAN: End-results of total thyroidectomy in angina pectoris. DAVID DAVIS: End-results of total thyroidectomy in congestive heart failure. HERRMAN L. BLUMGART: Indications and contra-indications for surgery, selection of cases. CHARLES G. MIXTER: General surgical considerations in total thyroidectomy. DAVID D. BERLIN: Technical considerations in total thyroidectomy. DAVID DAVIS: Treatment of postoperative complications. DOROTHY GILLIGAN: Parathyroid insufficiency following total ablation of the thyroid gland. MARK ALTSCHULE and ALFRED WEINSTEIN: Total thyroidectomy, moving picture demonstration; demonstration of cases.

CHARLES G. MIXTER, DAVID D. BERLIN and associates—2. Total thyroidectomy.

Wednesday

E. GRANVILLE CRABTREE and associates—9. Dry clinic, symposium on the female bladder: Demonstration of various factors related to function in health, pregnancy and disease; the use of urethrogram and cystogram in the diagnosis of bladder displacements and deformities in the multiparous woman, results of routine surgery in such cases; treatment of infections in the abnormal bladder.

W. JASON MIXTER—9. Craniotomy.

Staff—2. Dry clinic. CARL BEARSE: Acute appendicitis beyond the age of fifty. W. JASON MIXTER: Subject to be announced. ARNOLD STARR: Effect of diaphragmatic paralysis on the efficiency of cough. JACOB FINE: Postoperative distention, an experimental study. LOUIS NASON: Gas bacillus infection complicating laparotomy. BENJAMIN BANKS: Differential diagnosis of jaundice. I. R. JANKELSON: Indications for ileostomy in ulcerative colitis. CHARLES G. MIXTER: Regional ileitis. MAURICE BARRON: Is radical resection for carcinoma of the rectum the best procedure?

Thursday

Staff—9. Symposium on total thyroidectomy for chronic heart disease and angina pectoris. HERRMAN L. BLUMGART: Rationale of total thyroidectomy in chronic heart disease. JOSEPH RISEMAN: End-results of total thyroidectomy in angina pectoris. DAVID DAVIS: End-results of total thyroidectomy in congestive heart failure. HERRMAN L. BLUMGART: Indications and contra-indications for surgery, selection of cases. CHARLES G. MIXTER: General surgical considerations in total thyroidectomy. DAVID D. BERLIN Technical considerations in total thyroidectomy. DAVID DAVIS: The treatment of postoperative complications. DOROTHY GILLIGAN: Parathyroid insufficiency following total ablation of the thyroid gland. MARK ALTSCHULE and ALFRED WEINSTEIN: Total thyroidectomy, moving picture demonstration; demonstration of cases.

CHARLES G. MIXTER, DAVID D. BERLIN and associates—2. Total thyroidectomy.

E. GRANVILLE CRABTREE and associates—2. Bladder surgery, operative and dry clinic.

Friday

MARK ROGERS and associates—9. Orthopedic dry clinic: Methods and results of manipulation of subdeltoid bursitis; slipping epiphysis, femoral neck; club foot, demonstration of application of plaster cast; method of drainage of septic knees, posterior incision; stenosing tenovaginitis, operative results; Nicola operation, end-results in three cases of recurrent dislocation of the shoulder; marble bones, repeated fracture of the femur; fractures of the long bones in Paget's disease; compression fractures of the spine in diabetes and old age; correction of hallux valgus, temporary paralysis of the sensory nerve affecting the joint.

CHARLES G. MIXTER and associates—9. General surgical operations.

Staff—10:30. Dry clinic. WILLIAM DAMESHEK: Blood changes in surgical conditions. HYMAN MORRISON: Nonsurgical simulating acute surgical disease. HARRY DEROW: Significance of postoperative rise in nonprotein nitrogen. ARNOLD STARR and S. RICHARD MUELLNER: Postoperative renal suppression. CHARLES G. MIXTER: Surgery of the large intestine. S. GARGILL and M. FALCON-LESSES: Thyroid clinic experiences.

E. GRANVILLE CRABTREE and associates—2. Renal surgery.

Staff—2. Symposium on tumors. WILLIAM DAMESHEK: Malignancies of the blood forming organs. HARRY F. FRIEDMAN and LOUIS M. FREEDMAN: Laryngeal carcinoma, diagnosis and treatment, presentation of cases. REUBEN B. DAVIDOFF: Differential diagnosis of breast tumors. CHARLES G. MIXTER: Surgical treatment of breast tumors. HARRY F. FRIEDMAN: Radiation treatment of breast tumors. MONROE J. SCHLESINGER: The diagnosis of malignancy from ascitic and pleural fluids. HARRY F. FRIEDMAN and LOUIS ALBERT: Policy toward married women in regard to carcinoma of the uterine cervix. JACOB H. SCHWARTZ: Diagnosis of carcinoma of the skin. HARRY F. FRIEDMAN: Cinema of radium treatment of carcinoma of skin. SAMUEL A. ROBINS: Roentgen diagnosis of renal tumors. E. GRANVILLE CRABTREE: Surgery in renal tumors. GEORGE C. PRATHER: Results of surgery in renal tumors; testicular tumors.

Daily Exhibit in Medical Research Laboratories

WILLIAM DAMESHEK: Blood changes in surgical conditions. HERRMAN L. BLUMGART: Total thyroidectomy for chronic heart disease. HARRY A. DEROW: Renal function tests in surgery. SAMUEL A. ROBINS: Demonstration of interesting or unusual X-ray films. MONROE J. SCHLESINGER: Surgical pathological specimens with case histories.

BEVERLY HOSPITAL

Thursday

PEER JOHNSON and JOHN ADAMS—10. Fracture clinic.

PETER BENT BRIGHAM HOSPITAL

Monday

DAVID CHEEVER—2. Surgical clinic.
H. F. NEWTON—3. Thoracoplasty.
S. A. LEVINE—3:30. Circulatory emergencies in surgical patients.

Tuesday

Staff—9. General surgery, operative clinic.
E. C. CUTLER—2. Total thyroidectomy.
C. L. DERICK—3. Symptoms and diagnosis of vascular thrombosis.
JOHN HOMANS—3:30. Swollen legs.

Wednesday

Staff—9. General surgery, operative clinic.
HENRY A. CHRISTIAN—2. Medical clinic.
M. C. SOSMAN—3. Recent developments in diagnostic radiology.
E. S. EMERY, JR.—3:30. Results of surgical procedures for relief of peptic ulcer.

Thursday

Staff—9. General surgery, operative clinic.
W. C. QUINBY—2. Indications for and results of total cystectomy.
J. C. ECKELS and G. P. GRABFIELD—2:30. Denervated kidney, studied by means of the divided bladder.
M. S. STROCK—3. Methods of fixation of fractures of the jaw.
S. B. WOLBACH—3:30. Demonstration of surgical pathology.

Friday

Staff—9. General surgery, operative clinic.
DAVID CHEEVER—2. Cancer of the stomach.
F. C. NEWTON—2:30. Cancer of the rectum.
R. FITZ—3. Function of the spleen.
W. P. MURPHY—3:30. Treatment of pernicious anæmia, motion picture demonstration.
F. R. OBER—3:45. Treatment of neuromuscular sequelæ of pernicious anæmia.

HARVARD MEDICAL SCHOOL

Monday

G. KENNETH COONSE and OTTO AUFRANC—2. (Bldg. C). Demonstration of the mechanical factors controlling the pulmonary circulation.
CHARLES L. SCUDDER and associates—2. (Bldg. E). Symposium on fractures.

Tuesday

Building D—2

GEORGE B. WISLOCKI. Studies in mammalian reproduction.
VALY MENKIN. Some problems of inflammation related to surgery.
HENRY G. SCHWARTZ. An experimental study of sympathetic reflexes.
J. L. BREMER. The postnatal growth of the mammalian lung.
HAROLD L. WEATHERFORD. The finer changes in the liver cells in anaphylactic shock.
LESTER S. KING. Some aspects of the hæmato-encephalic barrier.

Building E—2

G. A. BENNETT and WALTER BAUER. Joint changes resulting from trauma.
HUGH K. WARD. Streptococcal infections.
CECIL K. DRINKER. The physiology of the lymphatic system and its bearing on certain problems in surgery.

Wednesday

Building C—2

HALLOWELL DAVIS. Effect of cerebral anæmia on the electrical response of the cortex.
M. I. GREGERSEN. The use of hypertonic sucrose solution to reduce cerebrospinal fluid pressure without a secondary rise.
WALTER B. CANNON. Some relations of the sympathetic nervous system to surgery.

Building B—2

DAVID CHEEVER. Surgical anatomy of the abdomen, demonstrations on cadaver.

Building E—2

FRANK OBER and associates. Orthopedic problems from Children's Hospital. A. H. BREWSTER: Scoliosis. J. KUHNS: Posture and postural scoliosis. P. NORTON: Posterior transplants. H. FITZSIMMONS: Congenital deformities.

Thursday

CHARLES L. SCUDDER and associates—2 (Bldg. E). Symposium on fractures.

Friday

Symposium on Industrial Surgery—2—Building C

JOHN D. ADAMS and W. A. ROGERS. Injuries of the back.
HENRY MARBLE, F. J. COTTON, and J. D. ADAMS. Injuries of the nervous system.
F. J. COTTON and J. H. BURNETT. Colles' fracture.

Orthopedic Clinic—2—Building E

W. GREEN. Osteomyelitis in infants and children.
R. H. MORRIS. Septic hips with involved heads.
A. T. LEGG. Osteomyelitis of the tarsus.
R. JOPLIN. Multiple myeloma.
A. H. BREWSTER. Peroneal spasm.
R. H. MORRIS. Knee flexion.

Daily

Warren Museum—M. Canavan, Curator—2

Demonstration of Dwight collection of spines illustrating deformities, anomalies, diseases. Bone tumors, with X-rays, histories, and microscopic slides, with microscopes available for examination (some of these specimens were used in the illustrations in the monograph on "Bone Sarcoma" issued by the American College of Surgeons). Models showing various types of club feet and effects of operation. Pictures illustrating pathological conditions of bone in Dr. Nichols' collection. Fractures and dislocations of bones as they existed before industrial plants provided so many safeguards. Tuberculosis of bones and joints. Syphilis of bones. Dislocation of ends of bones. Collection of old surgical instruments, obstetrical forceps, turnkeys for extracting teeth, urological tools, cupping and leeching instruments.

HARVARD UNIVERSITY

(Dillon Field House, Soldier's Field)
Opposite Harvard Stadium, Allston, Mass.

Wednesday

AUGUSTUS THORNDIKE, JR.—2. Care and prevention of traumatic injuries in athletics; demonstration of protective strapping, padding, and apparatus used in modern athletics.

ST. ELIZABETH'S HOSPITAL

Tuesday

JOSEPH STANTON—9. Subtotal thyroidectomy.
GEORGE KEENAN—9. Hysterectomy.
CHARLES KICKHAM—9. Supravaginal hysterectomy.
E. J. O'BRIEN—9. Transurethral resection of prostate.
E. M. HODGKINS—10. Repair of postincisional hernia with peritoneal fascial strips, by utilizing sac.
JOHN SPELLMAN—10. Radical operation for cancer of tongue.
THOMAS BRODERICK—10. Spine fusion.
BENEDICT BOLAND—11. Low transverse cervical section.
LAURENCE LOUIS—11. Total thyroidectomy.
Staff—2. Dry clinic. CHARLES KICKHAM: Series of spontaneous rupture of the uterus. RUSSELL SULLIVAN: End-results of bone and joint problems. LAURENCE LOUIS: Postoperative total thyroidectomy for (a) angina pectoris, (b) congestive heart disease. FRANCIS P. MCCARTHY: Frozen sections; demonstration and discussion of pathological specimens.

Wednesday

JOSEPH STANTON—9. Hysterectomy.
GEORGE KEENAN—9. Cholecystectomy.
RUSSELL SULLIVAN—9. Nicola operation for recurrence of dislocation of shoulder.
LAURENCE LOUIS—9. Radical operation, cancer of breast.
E. J. O'BRIEN—10. Nephrectomy for tuberculous kidney.
WILLIAM MCDONALD—10. Operation for correction of childbirth injury.
THOMAS BRODERICK—10. Reconstruction of hip joint.
M. MCGARTY—10. Removal of cartilage from knee joint.
EDWARD HODGKINS—11. Repair of recurrent inguinal hernia with fascial strips.
MARTIN SPELLMAN—11. Sacro-iliac arthrodesis.
Staff—2. Dry clinic. WILLIAM DOLAN: Industrial surgery. JOHN WHORISKEY: Diseases of the gall bladder, medical cases either refusing operation or being surgically unfit, demonstration of cases. FRANK JANTZEN: Cholecystitis and liver dysfunction (a) with hypopituitary syndrome, (b) with hypothyroid syndrome. MICHAEL MCGARTY: Flap graft in reconstruction of foot. JOHN CASEY: Disease of spleen from a surgical standpoint. THOMAS BRODERICK: Demonstration of spinal cases with operative technique, lantern slides.

Thursday

JOSEPH STANTON—9. Gastro-enterostomy.
BRYANT WETHERELL—9. Nephrectomy.
FRANK JANTZEN—9. Inguinal herniotomy under local anæsthesia.
EDWARD HODGKINS—9. Gastro-enterostomy.
THOMAS BRODERICK—10. Reconstruction of hip joint.
CHARLES KICKHAM—10. Prolapsed uterus with perineal repair and suspension.
WILLIAM DONOVAN—10. Suprapubic prostatectomy.
EDWARD O'BRIEN—10. Suprapubic cystostomy.
MICHAEL MCGARTY—11. Fascial repair of double recurrent inguinal hernia.
BENEDICT BOLAND—11. Tubal plastic for sterility.
Staff—2. Dry clinic. WILLIAM O'HALLORAN: Medicine from a pre-operative and postoperative standpoint. BRYANT WETHERELL: Discussion of diagnosis of carcinoma of bladder. WILLIAM MCDONALD: Polyneuritis in pregnancy. JAMES LYNCH: Vulval phlebitis complicating pregnancy, antenatal. JOSEPH STANTON: Hypocalcemia of unusual origin, gastric ulcer; demonstration of interesting clinical cases.

NEWTON HOSPITAL

Tuesday

E. D. LEONARD—9. Breast amputation.
G. M. MORRISON—9. Reconstruction of elbow.
G. K. COONSE—9. Operation for fractured patellæ.
E. G. CRABTREE—9. Cystotomy.
F. W. MARVIN—9. Pantocain anæsthesia.
D. G. NUTTER—9:15. Desmoid cysts of the abdomen.
R. I. SMITH—9:30. Carcinoma of the duodenum.
G. C. PRATHER—9:30. Renal calculus.
N. P. BRACKETT—10. Strangulated hernia in the aged.
D. G. NUTTER—10. Hysterectomy for fibroids.
G. K. COONSE—10. Triceps repair of olecranon fracture.
G. M. MORRISON—10. Ankle fractures.
F. R. CLARK—10. Cæsarean section.
H. WATTERS—10:15. Intussusception in infancy.
D. G. WILCOX—10:30. Pyosalpinx.
E. D. LEONARD—10:45. Paralytic ileus.
R. I. SMITH—11. Complete thyroidectomy for angina pectoris.
N. P. BRACKETT—11. Cholecystectomy.
H. G. DUNPHY—11. Ligation of saphenous vein for varicose ulcer.
Fracture and orthopedic services—9. Dry clinic: Demonstration of application of plaster casts, Boehler technique; application of Anderson well leg traction apparatus; treatment of fractures of the spine, including hyperextension, frames, jackets, etc.; treatment of Colles' fracture by Cotton-Loder method; demonstration of new type humeral traction abduction splint.
Staff—2. Symposium on obstetrics. E. GRANVILLE CRABTREE: Discussion of urinary tract infection in pregnancy. GEORGE C. PRATHER: Discussion of lone kidneys in pregnancy. F. R. CLARK, M. F. EADES, and G. E. MAY: Pre- and postoperative care of patients.
ROBERT G. VANCE—2. X-rays of traumatic skulls.

PALMER MEMORIAL HOSPITAL

Tuesday

Staff—9. Treatment of malignant disease, including surgery, electrosurgery, and radium implantation, operative clinic.
Staff—2. Dry clinics. G. A. LELAND: Carcinoma of cervix. FLETCHER COLBY: Urinary tract complications from carcinoma of the cervix. L. S. MCKITTRICK: Interstitial radiation for carcinoma of the breast. R. H. DRESSER: Irradiation of the ovary in cancer of the breast. GEORGE G. SMITH: Diversion of the urinary stream. JOHN HODGSON: Relief of pain in malignant disease.

Wednesday

Staff—9. Treatment of malignant disease including surgery, electrosurgery, and radium implantation, operative clinic.

Thursday

Staff—2. Dry clinics. D. F. JONES: Surgical management of carcinoma of the rectum. L. S. MCKITTRICK: Factors favoring early diagnosis of cancer of the colon, principles of treatment. R. H. SWEET: Polyposis of the colon. SHIELDS WARREN: Pathological aspects of rectal polypi. WYMAN RICHARDSON: Blood dyscrasias after gastrectomy and short-circuiting operations on the intestinal tract.

Friday

Staff—9. Treatment of malignant disease, surgery, electrosurgery, and radium implantation, operative clinic.

NEW ENGLAND DEACONESS HOSPITAL

Tuesday

F. H. LAHEY, H. M. CLUTE, R. B. CATTELL, and R. H. OVERHOLT—9. General surgical operations.

GILBERT HORRAX and JAMES POPPEN—9. Neurosurgical operations.

RICHARD H. OVERHOLT—9. Thoracic surgery operations.

G. E. HAGGART—9. Orthopedic operations.

JAMES B. HICKS—9. Urolological operations.

LINCOLN F. SISE, PHILIP E. WOODBRIDGE, and URBAN EVERSOLE—9. Anæsthesia.

F. H. LAHEY—9. Œsophageal diverticulum, dry clinic.

GILBERT HORRAX—9. Malignant exophthalmos, dry clinic.

Staff—2. Dry clinics. H. M. CLUTE: Management of obstructive jaundice; exploration of common duct. GILBERT HORRAX: Brain tumors; malignant exophthalmos. SARA M. JORDAN: Gastric cancer and ulcer; gastrojejunal ulcer. F. H. LAHEY: Total gastrectomy for cancer; gastrojejunal colic fistula; surgery of intractable ulcer. EVERETT KIEFER: Hæmorrhage in peptic ulcer. RICHARD B. CATTELL: Embolectomy; parathyroid tetany.

Wednesday

F. H. LAHEY, H. M. CLUTE, R. B. CATTELL, and R. H. OVERHOLT—9. General surgical operations.

GILBERT HORRAX and JAMES POPPEN—9. Neurosurgical operations.

RICHARD H. OVERHOLT—9. Thoracic surgery operations.

G. E. HAGGART—9. Orthopedic operations.

JAMES B. HICKS—9. Urological operations.

LINCOLN F. SISE, PHILIP D. WOODBRIDGE, and URBAN EVERSOLE—9. Anæsthesia.

Staff—2. Dry clinics. G. E. HAGGART: Subdeltoid bursitis; treatment of flexion deformities. JAMES L. POPPEN: End-results in trigeminal neuralgia; spinal fluid pressure dynamics. FRANK H. LAHEY: Œsophageal diverticulum; hyperthyroidism. H. M. CLUTE: End-results in hyperthyroidism. LEWIS M. HURXTHAL: Thyrocardiac patients. EVERETT KIEFER: Ulcerative colitis. RICHARD B. CATTELL: Surgical treatment of ulcerative colitis. RICHARD OVERHOLT: Limited thoracoplasty in pulmonary tuberculosis; cancer of lung.

Thursday

E. P. JOSLIN, H. F. ROOT, L. S. MCKITTRICK, and T. C. PRATT—9. Surgical and medical diabetic ward rounds.

T. C. PRATT—10:30. Thigh amputation for diabetic gangrene.

L. S. MCKITTRICK—10:30. Gritti-Stokes amputation for diabetic gangrene.

Staff—2. Dry clinic: Surgery in diabetes mellitus. E. P. JOSLIN: Medical care of the surgical patient. L. RICHARDS: Otolaryngological aspect of diabetes. J. H. WAITE: Cataract surgery in diabetes mellitus. Gangrene and infection of the lower extremities. H. F. ROOT: Preventive measures. L. S. MCKITTRICK: Factors influencing the level of amputation. T. C. PRATT: Indications for guillotine amputation. R. S. TITUS: Obstetrics in diabetes. MARK ROGERS: Depressed fracture of the spine in diabetes; subdeltoid bursitis in diabetes mellitus.

Friday

F. H. LAHEY, H. M. CLUTE, R. B. CATTELL, and R. H. OVERHOLT—9. General surgical operations.

GILBERT HORRAX and JAMES POPPEN—9. Neurosurgical operations.

RICHARD H. OVERHOLT—9. Thoracic surgery operations.

G. E. HAGGART—9. Orthopedic operations.

JAMES B. HICKS—9. Urological operations.

LINCOLN F. SISE, PHILIP D. WOODBRIDGE, and URBAN EVERSOLE—9. Anæsthesia.

Staff—2. Dry clinics. R. B. CATTELL: Cancer of the colon and rectum. GILBERT HORRAX: Root resection for trigeminal neuralgia; cordotomy for pain. JAMES POPPEN: Spinal cord tumors. RICHARD OVERHOLT: Cancer of the breast. JAMES B. HICKS: Transurethral resection of the prostate. H. M. CLUTE: Subphrenic abscess. F. H. LAHEY and FRANK N. ALLAN: Parathyroid tumors.

NEW ENGLAND HOSPITAL FOR WOMEN AND CHILDREN

Tuesday

LETITIA D. ADAMS, BLANCHE ATWOOD AND GRACE ROCHFORD—9. Surgical operations.

Staff—2. Dry clinics. GRACE ROCHFORD and MARJORIE WOODMAN: Dr. Alonzo Paine's method of delivering posterior positions, motion picture and manikin demonstration. ILIA GALLIANI: Carcinoma fundus in a young woman treated for amenorrhœa with Antuitrin S. ANSTIS MANTON: Fibrosarcoma of liver in child of six. FELICIA BANAS: Carcinoma of kidney with metastases in child of three. MIRIAM KATZEFF: Familial muscular dystrophy, demonstration of cases and motion pictures. BLANCHE ATWOOD: Demonstration of an unusual type of fracture of pelvis with special apparatus used. OLGA C. LEARY: Unusual pathological specimens with case histories.

Wednesday

LETITIA D. ADAMS, BLANCHE ATWOOD and GRACE ROCHFORD—9. Surgical operations.

MARJORIE WOODMAN, DR. FRIEDMAN, R. A. DRAPER, DR. GIBSON, E. A. POLCARI and M. K. MATARAZZO—9. Obstetrical clinic: Demonstration of analgesia, maternity ward rounds, prenatal clinics, parent-teaching clinics.

Thursday

LETITIA D. ADAMS, BLANCHE ATWOOD and GRACE ROCHFORD—9. Surgical operations.

Friday

LETITIA D. ADAMS, BLANCHE ATWOOD and GRACE ROCHFORD—9. Surgical operations.

ROBERT B. BRIGHAM HOSPITAL

Monday

L. M. SPEAR—2. Classification of types of arthritis.

L. T. SWAIM and J. KUHNS—3. Treatment and orthopedic principles involved in arthritis.

Tuesday

H. K. THOMPSON—2. Clinical analysis of arthritis with reference to classification and treatment.

P. D. WILSON and S. ROBERTS—3. Discussion of operative procedures, demonstration of end-results.

Wednesday

L. M. SPEAR—2. Classification of types of arthritis.

L. T. SWAIM and J. KUHNS—3. Treatment and orthopedic principles involved in arthritis.

Thursday

H. K. THOMPSON—2. Clinical analysis of arthritis with reference to classification and treatment.

P. D. WILSON and S. ROBERTS—3. Discussion of operative procedures, demonstration of end-results.

BOSTON DISPENSARY

Tuesday

Tumor clinic staff—9. Dry clinic. FRANK W. MARVIN: Anæsthesia in operative cases. CHARLES M. PROCTOR: Precancerous and benign lesions of the oral cavity. CHARLES E. DUMAS: Radium technique in malignancy of the throat. LEROY A. SCHALL: Treatment of cancer of tonsil. GEORGE S. SPEARE: Malignant degeneration of sebaceous cysts. LOUIS E. PHANEUF: Precancerous lesions and cancer of the cervix, lantern slide demonstration. ALICE ETTINGER: Early diagnosis of malignancy of gastro-intestinal tract by relief method. HAROLD A. CHAMBERLIN: Papillary tumors of the kidney pelvis. ROGER C. GRAVES: Management of cancer of penis with particular reference to a modified operation for advanced cases. MYRON J. HAHN: Cancer of the prostatic capsule. ISADORE OLEF: Management of malignancy of the lymphatic system. HILBERT F. DAY: Cancer of breast, end-results of dispensary and personal cases. JOEL ROSENBERG: Bleeding carcinoma of breast without tumor. WILLIAM M. SHEDDEN: Management of cancer of rectum with particular reference to irradiation. HAROLD MCMAHON: Relation of pathology department to tumor clinic.

Wednesday

Staff—10. Dry clinic. OLIVER G. TINKHAM: Clinical teaching of third year medical students. FRANCIS P. BARNUM: Use of adhesive plaster. P. A. CONSALES: Adenomatous changes in aberrant thyroid. HILBERT F. DAY: Management of a varicose vein clinic, where over 150 treatments a week are given. EDWARD T. WHITNEY: Varicose ulcers, demonstration of cases and treatment. WALTER S. LEVENSON: High ligation of varicose veins. WILLIAM M. SANTORO: Injection treatment of varicoceles. S. SEYMOUR HORLICK: Results of multiple injections of varicose veins at same visit. HILBERT F. DAY: Results of excision of sloughs following injection treatment.

Thursday

Staff—9. Dry clinic. JOHN D. ADAMS: Shueller-Christian disease (xanthomatosis); bone tumors. ROY E. MABREY: Chordoma and chondrosarcoma. WILLIAM A. HINTON: Detection of syphilis as an aid in practice of surgery. FRANCIS M. THURMON: Syphilis and the differential diagnosis of surgical conditions. JOSEPH SKIRBALL: Ophthalmic studies in syphilis. GRACE E. ROCHFORD: An unusual gynecological condition. LOUIS A. O. GODDU: Pain in the shoulder girdle. ROBERT W. BUCK: Kidney function; renal function tests. WILLIAM E. DAVIS: Some observations in treatment of peptic ulcer in out-patient clinic. ALICE ETTINGER: Diagnosis of activity of duodenal ulcer by X-ray. KATHERINE S. ANDREWS: Hiatus hernias. HILBERT F. DAY: Solitary gall-stone pain relieved by posture. Demonstration of interesting X-ray plates of peptic ulcer and gall-bladder disease.

WALTHAM HOSPITAL

Friday

R. L. DENORMANDIE, T. W. HARMER, D. MUNRO, J. D. BARNEY, J. W. SEVER, H. Q. GALLUPE, R. COLLINS, and H. A. WOOD—9. Surgical operations.

R. L. DENORMANDIE, T. W. HARMER, D. MUNRO, J. D. BARNEY, J. W. SEVER, H. Q. GALLUPE, R. COLLINS, and H. A. WOOD—2. Dry clinics: General surgery, orthopedics, obstetrics, pathology, etc.

FREE HOSPITAL FOR WOMEN

Tuesday

F. A. PEMBERTON, G. V. SMITH, and S. C. GRAVES—9. Operative and dry clinic: Carcinoma of cervix uteri, treatment and results, prevention, diagnosis of early cases, relation to cervicitis and its treatment, complications of radium treatment, relief of pain; carcinoma of fundus uteri, treatment and results, classification; other tumors of uterus—fibroids, adenomyoma.

Wednesday

F. A. PEMBERTON, G. V. SMITH, and PAUL YOUNGE—9. Operative and dry clinic: Tumors of the ovary, diagnosis, treatment, and results. Cystadenoma, granulosa cell tumor, Brenner tumor, teratoma; endometriosis, diagnosis and treatment; tumors of tubes, round ligaments, and vagina.

Thursday

G. V. SMITH and JOHN ROCK—9. Operative and dry clinic: Sterility, diagnosis, treatment and results; menorrhagia and metrorrhagia, diagnosis, treatment and results; endocrine research; dysmenorrhœa.

Friday

F. A. PEMBERTON, E. B. SHEEHAN, and S. C. GRAVES—9. Operative and dry clinic: Prolapse, procidentia; complete tear of perineum; vesico- and rectovaginal fistulæ; kraurosis vulvæ, carcinoma vulvæ; Trichomonas vaginale; tumors of breast, value of X-ray treatment.

PONDVILLE STATE CANCER HOSPITAL

Tuesday—2

ERNEST M. DALAND. The Massachusetts cancer program.
HENRY JACKSON, JR. Some aspects of malignant lymphoma.
JOE V. MEIGS. Ovarian tumors.
LANGDON PARSONS. Treatment of cancer of the cervix by X-ray followed by radium.
ROGER GRAVES. Cancer of the prostate with metastases.
CHARLES KICKHAM. Cancer of the penis.
CHARLES DUMAS. X-ray treatment of advanced skin cancer, demonstration of cases.

Friday—2

GRANTLEY TAYLOR. Radium needles in cancer of breast.
HORATIO ROGERS. Chronic cystic mastitis.
RICHARD DRESSER. X-ray in the diagnosis of gastro-intestinal cancer.
SHIELDS WARREN. Changes in tumor tissue caused by radiation.
JOHN HODGSON. Treatment of pain in cancer patients.
CARL ERNLUND. Cancer of the antrum, demonstration of cases.

INDUSTRIAL SURGERY

Tuesday

H. C. MARBLE and H. P. TOWLE (142 Berkeley Street)—9.
D. LYNCH and B. GODVIN (245 State Street)—9.

Wednesday

G. W. MORSE (31 St. James Avenue)—9.

Thursday

WILLIAM DOLAN (110 Milk Street)—9.

Friday

J. H. SHORTELL (260 Tremont Street)—9.
D. LYNCH and B. GODVIN (245 State Street)—9.

FAULKNER HOSPITAL

Wednesday

F. J. COTTON, E. G. BRACKETT, and associates—9. Bone and joint clinic, operative and dry.

Staff—2. Dry clinic. E. G. BRACKETT: Hip fracture. F. J. COTTON: Bone tumors; fractures of pelvis. H. C. MARBLE: Hand surgery; fractures of the forearm. J. D. ADAMS: Industrial lesions of the knee. WILLIAM A. ROGERS: Compression fracture of spine. E. A. CODMAN: Shoulder lesions. B. GODVIN: Os calcis fractures. W. F. COTTING: Ankle fractures. H. K. SOWLES: Elbow fractures. Demonstration of X-ray plates and pathological specimens.

Thursday

J. L. YOUNG, JR., R. C. COCHRANE, A. R. KIMPTON, and associates—9. Operative clinic.

R. TORBERT and R. S. TITUS—11. Obstetrical clinic.

W. WIGGIN—11. Postoperative pulmonary complications.

Staff—2. Symposium on pre-operative immunization of the peritoneal cavity: H. L. JOHNSON: Theoretical and experimental evidence of the benefit of amfetin. E. L. YOUNG, JR. and EVERETT O'NEIL: Clinical evidence of immunity from amfetin injection. R. C. COCHRANE and BURTON HAMILTON: Total thyroidectomy for heart disease. F. G. BALCH, JR.: Injection treatment of hæmorrhoids.

COLLIS P. HUNTINGTON MEMORIAL HOSPITAL

Monday

Staff—2:15. Tumors and diseases of bones, dry clinic. J. C. AUB: Calcium metabolism in diseases of the bones. CHANNING C. SIMMONS: Malignant tumors of bone. RICHARD DRESSER: Radiological diagnosis of bone tumors and certain rare forms of skeletal diseases. C. C. FRANSEEN: The phosphatase content of the blood in bone tumors and skeletal diseases.

GEORGE A. LELAND and J. V. MEIGS—3:30. Carcinoma of the cervix.

Friday

Staff—2:15. Carcinoma of the oral mucous membrane, dry clinic. CHANNING C. SIMMONS: Choice of treatment in the individual case. C. C. LUND: Results of treatment of cancer of lip. GRANTLEY W. TAYLOR: Carcinoma of the mouth in the female. RICHARD DRESSER: Radiation treatment of oral carcinoma. CHARLES B. HOPKINS: Prophylaxis of cancer of the mouth. SOMERS STURGIS: Electrical currents between fillings of different metals as an etiological factor in leucoplakia and carcinoma of the mouth.

E. W. HERMAN and LEROY A. SCHALL—3:30. Carcinoma of the accessory sinuses, tonsils, and larynx.

STATE PRISON COLONY

Day to be announced

HILBERT DAY. Practice of medicine in a modern correctional institution.

WILFRED BLOOMBERG. Psychiatric approach to prison medicine.

HENRY R. CRAIG. Unusual incidence of peptic ulcer in a prison population.

GEORGE H. LYONS. Minor surgical injuries in a protected population.

GEORGE ROTHBLATT. Dental conditions causing personality changes.

CAMBRIDGE HOSPITAL

Tuesday

Staff—9. General surgical operations.

Staff—9. Dry clinic. A. W. DUDLEY: Subject to be announced. H. F. DAY, E. H. MCMAHON and H. P. STEVENS: Lipoid degeneration of uterus. SOMERS FRAZER: Subject to be announced. DAVID ROSE: Subject to be announced. C. T. O'CONNOR: Cæsarean section. H. L. SEVER: Delivery of a living child from dead mother. E. H. MCMAHON: Pathological subject to be announced. T. H. LANMAN, P. J. MAHONEY and J. W. NICHOLS: Subject to be announced. W. STEWART WHITTEMORE: Subject to be announced.

Staff—2. Dry clinic. A. H. CROSBIE and H. A. CHAMBERLAIN: Horseshoe kidney. H. F. DAY: Effect of posture on the solitary gallstone. S. S. HANFLIG: Osteomyelitis. STANLEY NOWAK: Subject to be announced. OSCAR RAEDER: Subject to be announced. H. P. STEVENS: Analysis of cases of biliary surgery.

NEW ENGLAND BAPTIST HOSPITAL

Tuesday

HALSEY B. LODER—9. Operative clinic.

Staff—9. Dry clinics. HALSEY B. LODER: Portal thrombosis; ulcerative colitis; gall stones, pancreatitis; uterine fibroids. A. A. HORNOR: Ulcerative colitis. ROBERT L. DENORMANDIE and DELOS J. BRISTOL: Blood transfusion in obstetrics; management of borderline obstetrical cases; anæsthesia and analgesia in obstetrics; prevention of eclampsia.

Thursday

F. H. LAHEY, H. M. CLUTE, R. B. CATTELL, and R. H. OVERHOLT—9. General surgery, operative clinic.

GILBERT HORRAX and JAMES POPPEN—9. Neurosurgical operations.

G. E. HAGGART—9. Orthopedic surgery.

JAMES B. HICKS—9. Urological surgery.

LINCOLN F. SISE, PHILIP D. WOODBRIDGE, and URBAN EVERSOLE—9. Anæsthesia.

BOSTON LYING-IN HOSPITAL

Tuesday and Thursday

FREDERICK C. IRVING and associates—9. Obstetrical operations; demonstrations of premature nursery, X-ray department, research laboratories, and hospital wards.

FREDERICK C. IRVING and associates—2. Dry clinic: Fetal roentgenometry; anæmia in pregnancy; treatment of heart disease in pregnancy; treatment of diabetes in pregnancy; management of neglected cases of cephalopelvic disproportion; treatment of placenta prævia; separation of the symphysis pubis; kidney function tests in pregnancy; classification of the albuminuric and hypertensive conditions in pregnancy; factors which make for viability in premature infants; erythroblastosis fetalis; barbiturates and other analgesic drugs in labor.

SYMMES ARLINGTON HOSPITAL

Tuesday

F. J. COTTON—9. Bone and joint surgery.

A. L. BRETT—9. Tumor of the spinal cord; shoulder arthrodesis.

G. P. TOWLE—9. General surgery.

S. G. JONES—9. Volkmann's paralysis.

EVANGELINE BOOTH MATERNITY HOSPITAL

Wednesday

A. K. PAINE, H. S. FINKEL, W. J. MCDONALD, M. G. BERLIN, J. HOPKINS, D. GOLDFARB, A. A. LEVI, J. J. CONWAY, H. BAKER, S. OSGOOD, and R. T. PHILLIPS —9. Gynecological operations and obstetrical procedures.

Staff—2. A review by demonstration, charts, pictures, and exhibits, of the obstetrical experience of the Booth Hospital: Maternal mortality, factors responsible for the declining rate at the Booth Hospital; the bleeding cases, statistics, management, and results; obstetrical sepsis; amnesia, analgesia, and anæsthesia in labor, results from the standpoint of safety, efficiency, effects on operative incidence, cæsarean section, incidence, indications, and mortality; toxæmia of pregnancy, treatment, methods and results over a fourteen year period; "debunking" pelvimetry; heart disease complicated by pregnancy; fetal mortality, analysis of four hundred cases, pathology.

MASSACHUSETTS WOMEN'S HOSPITAL

Thursday

HENRY T. HUTCHINS—9. Panhysterectomy.

STEPHEN RUSHMORE—9. Plastic laparotomy.

WILLIAM A. WHITE, JR.—9. Laparotomy.

REGINALD MARGESON—9. Transverse cervical cæsarean section.

ROBERT L. MASON—9. Thyroidectomy.

Staff—2. Dry clinic. CHARLES H. LAWRENCE: Endocrine sterility, end-results. DONALD MACOMBER: Problems of sterility. CHARLES F. PAINTER: Congenital obturator dislocation of right hip; causes of eburnation of bone. J. STEWART ROONEY: Pathological specimens.

LAKEVILLE SANATORIUM

Wednesday

Z. B. ADAMS—9:30. Ankylosis of hip, operative. Ward rounds.

Staff—2. Dry clinic: Tuberculosis of lymph nodes, genito-urinary tract, eye, gastro-intestinal tract, peritoneum, and skin.

Z. B. ADAMS—2. Orthopedic dry clinic.

MALDEN HOSPITAL

Wednesday

L. E. PHANEUF and N. A. GALLAGHER—9. Gynecological operations.

R. SULLIVAN—9. Orthopedic clinic.

L. W. MCQUIRE—9. Amœbic dysentery and its complications.

C. F. LYNCH, D. J. DUGGAN, I. J. WALKER, and F. W. GAY—2. Surgical operations.

Staff—2. Dry clinic. J. S. ROONEY: Pathological demonstration. I. J. WALKER: Discussion of jaundice with demonstration of liver specimens. L. SILVA: Discussion of coronary and gall-bladder disease in middle-aged people with electrocardiographic tracings. C. H. STAPLES: Hyperpituitarism, demonstration of cases.

CHELSEA MEMORIAL HOSPITAL

Thursday

Staff—9. Dry clinic. CHARLES P. SHELDON: Septic abortions. LLEWELLYN H. ROCKWELL: Perforated duodenal ulcer. GEORGE A. MARKS: Acute appendicitis with peritonitis. SYLVESTER B. KELLEY: Causes of death in prostatitis.

Staff—2. General surgical operations.

Staff—2. Dry clinic. GORDON MORRISON: Abdominal trauma. STEPHEN G. JONES: Volkmann's contracture. ALEXANDER P. AITKEN: Epiphyseal separation of the radius. JOHN S. HODGSON: Fractures of the skull. Discussion by FREDERICK J. COTTON.

LONG ISLAND HOSPITAL

Wednesday

R. H. MORRIS and T. H. PETERSON—9. Fracture clinic: Fracture of the neck of the femur in elderly people; demonstration of Soutter traction apparatus.

H. R. VIETS—9. Neurosurgical diagnosis.

J. H. CUNNINGHAM and C. S. SWAN—9. Urological operations.

A. S. MACMILLAN—2. X-ray demonstration.

I. B. AKERSON—2. Pathological demonstration.

C. L. SWAN, R. I. SMITH, and T. C. PRATT—2. General surgical operations.

SURGERY OF THE EAR, NOSE AND THROAT

MONDAY

H. DAVIS, H. A. DERBYSHIRE, and M. H. LURIE—Harvard Medical School, Bldg. C—3. Physiological experiments on the hearing of animals with the technique first reported by Wever and Bray; report of the pathological conditions found in animals with abnormal hearing, demonstrating technique and apparatus used; physiological experiment conducted on animal with the apparatus used, demonstrating (1) auditory response obtained from the cochlea itself; (2) auditory response from the cochlear nerve and its various ganglion centers in the midbrain; (3) auditory response as obtained from the cortex of the animal in the temporal lobe; (4) the effect of anæsthetics on these electrical responses; (5) demonstration of masking of tones in the cochlea.

TUESDAY

Staff—Massachusetts Eye and Ear Infirmary—9. Operations and demonstration of cases.

WALTER B. HOOVER—New England Deaconess Hospital—9. Osteoma of sinuses; laryngeal and tracheal complications of thyroid surgery; lingual tonsils and lateral bands of pharyngeal lymphoid tissue; syndrome of anæmia, glossitis, and dysphasia.

JOSEPH W. ROCKETT and THOMAS E. DINAN—Cambridge City Hospital—9. Tonsillectomies with gas-oxygen anæsthesia; presentation of cases of lateral sinus thrombosis.

F. G. MINITER and associates—Carney Hospital—9. Operation and demonstration of cases.

WILLIAM T. HALEY—St. Elizabeth's Hospital—11. Operation for correction of dislocation of nasal septum.

H. P. MOSHER—Harvard Medical School, Bldg. B—2. Exhibition of anatomical cases demonstrating the anatomy of the nose and throat; discussion of teaching methods; demonstration on the cadaver of the submaxillary approach for deep pus in the neck. P. E. MELTZER and M. H. LURIE: Exhibition of specimens illustrating the anatomy of the ear.

Staff—Beth Israel Hospital—2. L. M. FREEDMAN: Experiences with vocal cord paralysis in thyroidectomy. JACOB FINE: Technique for relief of bilateral recurrent nerve injury. CHARLES GETTES: Demonstration of technique for eliciting vestibular reactions by galvanism. L. M. FREEDMAN: Jugular puncture in mastoiditis. S. CLINE: Tuberculous laryngitis and its treatment. S. GARFIN: Treatment of malignant tumors of the upper respiratory tract. L. M. FREEDMAN: Bronchoscopic studies.

F. E. GARLAND—Massachusetts Eye and Ear Infirmary, Hooper room. Demonstration of historical instruments.

WEDNESDAY

Staff—Massachusetts Eye and Ear Infirmary—9. Operations and demonstration of cases.

WALTER B. HOOVER—New England Deaconess Hospital—9. Operations.

F. G. MINITER and associates—Carney Hospital—9. Operations and demonstration of cases.

Staff—Children's Hospital—9. LYMAN RICHARDS: Acute laryngotracheobronchitis. MAURICE EVANS: Bilateral jugular ligation and its neurological complications. PHILIP MYSEL: Cerebral abscess. CHESTER MILLS: Sinusitis. JOSIAH E. QUINCY: Radical mastoid operation. CHARLES ALLMAN: Unusual foreign bodies. ELMER GILLESPIE: Complications in simple mastoidectomy. SAMUEL CLINE: Cases of sinus thrombosis.

HARRY J. INGLIS and associates—Boston Dispensary—9. Dry clinic. LOUIS WOLFSON: Bronchoscopy in the upright position as an out-patient procedure. A. I. COHEN, F. S. DUSHAN, and FRANCIS STERN: An improved method of skin testing in allergic disturbances of nose and throat.

JOHN BURNS—St. Elizabeth's Hospital—11. Radical sinus operation under nerve block.

F. E. GARLAND—Massachusetts Eye and Ear Infirmary, Hooper room. Demonstration of historical instruments.

THURSDAY

Staff—Massachusetts Eye and Ear Infirmary—9. Operations and demonstration of cases.

WALTER B. HOOVER—New England Baptist Hospital—9. Operations.

E. J. BUTLER and C. H. ALLMAN—Cambridge Hospital—9. Operative and dry clinic. Hæmatogenous infection of left mastoid with extradural abscess in a nine months old child; pneumococcus type III meningitis with labyrinthitis, demonstration of case.

F. G. MINITER and associates—Carney Hospital—9. Operations and demonstration of cases.

C. FAUNCE—Faulkner Hospital—11. Operations and demonstration of cases.

WILLIAM T. HALEY—St. Elizabeth's Hospital—11. Radical operation for maxillary antrum.

JOHN BURNS—St. Elizabeth's Hospital—11. Radical mastoid operation.

F. E. GARLAND—Massachusetts Eye and Ear Infirmary, Hooper room. Demonstration of historical instruments.

FRIDAY

Staff—Massachusetts Eye and Ear Infirmary—9. Operations and demonstration of cases.

WALTER B. HOOVER—New England Deaconess Hospital—9. Operations.

F. G. MINITER and associates—Carney Hospital—9. Operations and demonstration of cases.

Staff—Massachusetts Eye and Ear Infirmary—9. Dry clinic. H. P. CAHILL: The present status of brain abscess from the standpoint of the otologist. P. E. MELTZER: A twelve year summary of cases of lateral sinus thrombosis at the Infirmary. P. MYSEL: A ten year review of cases of labyrinthitis at the Infirmary. D. C. SMYTH: Chest cases requiring bronchoscopy, lantern slide demonstration. A. S. MACMILLAN and D. C. SMYTH: The accessory sinuses from the standpoint of the roentgenologist and the clinician. A. S. MACMILLAN: Petrositis from the X-ray standpoint. G. H. POIRIER: Result of the Mosher-Toti tear sac operation. M. H. LURIE: Histological slides showing the pathological condition of the internal ear. E. W. HERMAN: Radium and X-ray treatment of cancer of the larynx. HARRIS P. MOSHER: Notes on œsophageal cases. F. E. GARLAND: Surgery of the submaxillary gland. C. G. PAGE: Fungi in tracheal and bronchial mucous. GEORGE L. TOBEY, JR.: The Tobey-Ayer test.

F. E. GARLAND—Massachusetts Eye and Ear Infirmary, Hooper room. Demonstration of historical instruments.

Days to be announced

ISABELLA D. KERR—New England Hospital for Women and Children. Avertin anæsthesia in tonsillectomies.

MARGARET NOYES KLEINERT—New England Hospital for Women and Children. Mastoidectomies in infants.

CHARLES I. JOHNSON, DONALD H. MACDONALD, and EDGAR M. Holmes—Newton Hospital. Operations and demonstration of cases.

L. F. JOHNSON—Massachusetts Memorial Hospital. Bronchoscopic operative clinic.

C. W. BUSH, R. O. PARRIS, and B. N. WEIN—Massachusetts Memorial Hospital. Operations.

H. L. BABCOCK—Massachusetts Memorial Hospital. Otological problems in contagious diseases.

A. W. ROWE and D. W. DRURY—Massachusetts Memorial Hospital. Endocrine factors in deafness.

OLIVER A. LOTHROP—Newton Hospital. Tonsil, sinus and septum operations; reduction of recent fractures of the malar and nasal bones; discussion of the indications for mastoid and sinus surgery.

SURGERY OF THE EYE

MONDAY

Staff—Massachusetts Eye and Ear Infirmary—2. Operations.

V. G. CASTEN—Massachusetts Eye and Ear Infirmary—2. Visual fields in neurological cases.

T. L. TERRY—Massachusetts Eye and Ear Infirmary—2. Pathological demonstration.

J. H. WAITE and associate—New England Deaconess Hospital—2. The eye in diabetes.

W. B. LANCASTER—520 Commonwealth Ave.—2. The Eikonometer.

TUESDAY

H. B. C. RIEMER and assistant—Massachusetts Eye and Ear Infirmary—9. Operations.

A. J. BEDELL—Massachusetts Eye and Ear Infirmary—9. Technique in photographing the fundus.

J. W. WHEELER—Massachusetts Eye and Ear Infirmary—9. Plastic operations.

HENRY M. EMMONS, WILLIAM D. ROWLAND and JOSEPH J. SKIRBALL—Massachusetts Memorial Hospital—9. Operations.

J. S. FRIEDENWALD—Massachusetts Eye and Ear Infirmary—9. Slit-lamp ophthalmoscopy.

PETER MCADAMS—St. Elizabeth's Hospital—11. Operations.

WEDNESDAY

J. H. WAITE and assistant—Massachusetts Eye and Ear Infirmary—9. Operations.

A. J. BEDELL—Massachusetts Eye and Ear Infirmary—9. Technique of photographing the fundus.

F. H. VERHOEFF and assistant—Massachusetts Eye and Ear Infirmary, Howe Laboratory—9. Operations and demonstration of cases.

Staff—Carney Hospital—9. Operations.

Staff—Boston Dispensary—9. The eye and syphilis.

HUGH DONAHUE—St. Elizabeth's Hospital—11. Operation for cataract.

ALLEN GREENWOOD—Massachusetts Eye and Ear Infirmary—2. Fundus cases.

T. L. TERRY—Massachusetts Eye and Ear Infirmary—2. Contact glasses.

Staff—Massachusetts Eye and Ear Infirmary—2. Motion picture demonstration of operations.

J. J. REGAN, SOMA WEISS, and DONALD MUNRO—Boston City Hospital—2. The eye in arteriosclerosis.

V. G. CASTEN—Long Island Hospital—2. Operative and dry clinic.

THURSDAY

E. K. ELLIS and assistant—Massachusetts Eye and Ear Infirmary—9. Operations.

H. B. C. RIEMER—Massachusetts Eye and Ear Infirmary—9. External diseases of the eye.

C. N. SPRATT and others—Massachusetts Eye and Ear Infirmary—9. Motion pictures of operations.

WILLIAM LIEBMAN and BENJAMIN SACHS—Beth Israel Hospital—10. Cataract extraction; muscle advancement; demonstration of cases.

HENRY M. EMMONS, WILLIAM D. ROWLAND and JOSEPH J. SKIRBALL—Massachusetts Memorial Hospital—2. Dry clinic.

FRIDAY

W. H. LOWELL and assistant—Massachusetts Eye and Ear Infirmary—9. Operations.

DR. MCCARTHY—Massachusetts Eye and Ear Infirmary, Howe Laboratory—9. Color vision testing.

J. J. REGAN—Boston City Hospital—9. Operations.

V. G. CASTEN—Massachusetts Eye and Ear Infirmary—2. Neurological cases; ocular paralysis.

T. L. TERRY—Massachusetts Eye and Ear Infirmary—2. Pathological demonstration.

E. B. DUNPHY—Massachusetts Eye and Ear Infirmary—2. Traumatic cases, operations and results.

J. J. REGAN and W. B. CASTLE—Boston City Hospital—2. The eye in anæmic patients.